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THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. XI.—*On the Observation of Sudden Phenomena;* by S. P. LANGLEY.

[Read before the Philosophical Society of Washington, March 2, 1889.].

BY a sudden phenomenon is here meant one of that large class where the occurrence is awaited without the observer's previous knowledge of its exact instant, and of which familiar examples may be found in the bursting of a rocket, the appearance of a meteor, or the emergence of a star from behind the moon. A great part of all the phenomena of daily life, as well as of scientific observation, are of this kind, though the importance of a special instance of another class, (I refer to the gradual and foreseen approach of a star to a wire), has drawn to this latter such particular attention that we are apt to think of it only when "personal error" is in question.

When in an observatory, we study the means taken to record the precise time of the transit of a star, we find that the precision of modern apparatus has reduced the error which we may expect in almost any part of the mechanism to an extremely minute amount, which may be calculated to the fractional part of the one hundredth of a second. I say "almost" for, as we are all aware, there is one notable exception, at least until photography can be made to intervene. The human brain and nerves, and behind these the inscrutable processes of the will, themselves form an inevitable link in the chain of apparatus of observation, and here an error may and

does arise enormously greater than that of all the rest put together.

We all know that this error varies with the individual and the occasion. It is most constant in the experienced observer, but even in his case it varies with the daily accidents of the human organism, and even with him it is presumably constant only for the particular observation to which the experience applies. There is not even a presumption, I think, that the personal equation belonging to an experienced transit observer would apply to the same person's notation of the occultation or emergence of a star, and still less, if possible, to any phenomenon outside his ordinary professional experience; for we must, of course, recognize that we carry this fallibility with us in every act of life, and that it is just as present when we attempt to determine the instant at which a race horse passes the winning post, as when we seek to note the particular hundredth of a second at which a star passes the wire.

The very words "personal equation" imply that the errors due to this fallibility can be ascertained and allowed for, and may lead us to think (if we think carelessly) that there is a personal equation always ascertainable; whereas, as we in fact know, it is only possible to apply the correction where long habit has settled the amount of error to be expected with regard to some one special phenomenon.

The number of devices for obtaining and correcting the personal equation, even in the special case of meridian observation, is, as those who have studied the subject know, surprisingly great. I think I have myself examined more than fifty such, and with hardly an exception they all exhibit variations on one idea—the idea, that is, that the error must have been committed *first;* the committing of the error being assumed to be an inevitable necessity for which subsequent correction is to be made.

I have thought, then, that it might be interesting if I were to ask you to consider with me what may seem at first the somewhat paradoxical suggestion, that means may be found by which any individual, skilled or ignorant, may make, not only meridian observations, but an observation of any sudden visible event, of whatsoever nature, so accurately that we need apply no correction, because the precision may be, if not absolute, at least such that no correction will in ordinary practice be needed. I may deceive myself in thinking that what I have to suggest involves a novel idea, but I am led to suppose so from the fact that I have met no application of it in a somewhat extended reading on this point.

Let me first remark that while such error as that in question doubtless belongs to all the senses in some degree, we are at this moment considering it in connection with the sense of sight only.

When we see anything in motion (let us suppose for instance a passing train on the railroad) we have the well-known facts that—

First. An instantaneous photograph is made by the optic lens upon the retina, there being a picture formed there, which is perfectly distinct, but which fades out upon the retinal plate in from one-tenth to one-quarter of a second, while the perception of this image is under ordinary circumstances * sensibly instantaneous; but—

Second. Nerves convey the distinct impression of every part of the picture to the brain, and it is here, if we have to act on this impression, that a certain time is lost, not only in the carrying of the message along one set of nerves and the bringing back the answer on the other, but in the decision that is being made by that unknown and inner self, which appears to us to exert here a more or less conscious act of will.

In the case of a sudden and startling event, the time elapsed may be almost indefinitely great; and in some cases, probably several entire seconds may pass without the consciousness of the observer. A very imperfectly appreciated interval must occur in all cases, for what we have just said applies to every event of our daily lives, and the professional observation is only a particular instance of it.

Now, I ask your attention to the practical instantaneity of the *formation* of this visual picture, which is known to be obtained where the duration of the phenomenon to be observed is much less than the one thousand-millionth of a second, while where we have every reason to believe that the actual formation of the image on the retina under known ordinary conditions requires a time of like order.

We may say, then, that the casting of a picture on the retina is instantaneous. It is its fading out that requires time, and it is while this fading out takes place, and even long after it, that the work of perception, decision, and action is going on behind the retinal curtain in the chambers of the brain. Notice then, that while to determine *when* a phenomenon occurs may require, under some circumstances, several seconds, and under all ordinary circumstances a notable fraction of a second, to determine *where* it occurs requires (sensibly) no time at all, for one single impression remains on the retina

* The writer's observations (this Journal, Nov., 1888) show that appreciable time is required for perception of the retinal impression, with certain excessively faint lights; but these are not here in question.

long enough to obtain full recognition and to be reproduced by processes of memory.

I can make my meaning clearer, perhaps, by using the same specific instance as before. Let us suppose that an accident to a passenger on the passing train is the phenomenon, the time of whose occurrence is to be noted, and that this accident is seen from a room in which there are two windows looking on the track. We must have seen the accident, if it be instantaneous, either through the first window or the second. If we had been led to anticipate that we should be called upon to say through which window we saw it, I think we may all admit that there would be no discrepancy on this point between different observers, for in this case we are considering only the element of position, and the element of time does not directly enter at all, so that observers in the same position who had been bidden to note through which window they saw it would all agree on this point.

Now a connection can here obviously be established between the place and the time, from which to infer the latter, if we are granted the knowledge of two facts: the time at which the carriage could have first come into view from the first window, and the time at which it must have passed out of view behind the second; for if we suppose the speed of the train to have been uniform, we have the means of deciding the fraction of the time when we know the fraction of space. Here then, as in the case of a common clock or chronograph, or any device where time and space are proportional, we can infer the latter from the former; only let it be observed that we here need no recording apparatus. What we use is the memory of where the event occurred; in other words, we recall the impression on the retinal screen and have no need to bring into use what we may call the time-perception apparatus of the brain which lies behind it; *nor do we in fact need that the object of our observation shall be really in motion, but only that it shall be made to appear to be so.*

This last point is all important, and what I ask your attention to is an experiment heretofore, I think, untried, and which is perhaps a novel application of the fundamental horological idea that time and space must be made proportional, for it seems to me it must be theoretically possible, not only in the case of the clock or the chronograph, but always, to so connect the former with the latter that the essential task of the time observer is only to say *where* any visible event apparently occurred, and then let some mechanism outside of himself say when.

That at least is the idea, and if it has, as I hope, been clearly apprehended by you, I will now ask your attention to a work-

ing plan for carrying it out. Numerous different devices have been under my consideration. I will take one which is primarily designed for the observation of any celestial phenomenon, though it could very well be adapted to terrestrial ones; and in order to fix our ideas, I will suppose that we have an event which we know the approximate time of, but which may burst upon us at some fraction of a second which we want to determine. I will assume (merely to fix our thoughts) that we wish to note the time at which a star emerges from behind the dark body of the moon, with an accuracy which ensures us that we have not made an error so great as one-twentieth of a second.

You see I hold in my hand a peculiar eye-piece, which has been made to observe this or any other terrestrial or celestial phenomenon of sudden occurrence. It can also be used for meridian observation, but its special field seems to lie in noting an event where no ordinary correction for personal equation is applicable. This event may be anything celestial or terrestrial, from the entrance of Venus on the disc of the sun, to the explosion of a mine; but, for the purpose of illustration merely, let us take it to be the sudden appearance of the star.

On looking into the telescope we see, in the first place, two prominent wires crossing each other at right angles, dividing the field of view into four quadrants. Now, by a simple mechanism, which I shall shortly explain, any object that our telescope is directed on—any fixed star for example—seems to be revolving in the field, passing successively through the first, second, third and fourth quadrants. If the star is hidden the mechanism is working just the same, and when the star appears it must evidently first be seen in some particular one of these four quadrants, and experience shows that we shall have no difficulty in telling in which one. The mechanism itself has recorded for us by an electric contact the limiting instant between which it is possible to see the beginning and the end of the cycle during which revolution may be supposed to be made. It is not necessary that this cycle should last just a second; but supposing it (still for illustration only) to be a second, if it was seen in the first quadrant, it was seen in the first quarter of the second; if it was seen in the second quadrant; some time in the second quarter of the second; in the third, in the third quarter; in the fourth, in the final quarter. All that we have to do in this case is to know in which second it occurred; for the quarter of a second we may say is noted for us by the purely automatic action of the optic lens and retina, since the first image on the retina must be that of the star as seen in some particular one of the four quadrants.

Going a little farther, we will now suppose each of the four quadrants, which in turn correspond to quarter seconds, to be

divided into five parts, so that the whole circle is divided into twenty. All the observer has to say is in which quadrant and in which subdivision of the quadrant the star appears, to say in which twentieth of the second (or other brief cycle) it emerged.

The reticule I have just described is fixed in the focus of the eye-piece and does not revolve. What does revolve is a minute double prism of total reflection just before the reticule, the middle of whose reflecting face lies in the optical axis, and by whose means this axis is twice broken at a right angle, so that when the telescope is directed on a star the image of the star is not seen at the center of the field, but on one side of it. If the prism is revolved, the star must appear to revolve in a circle whose radius is nearly that of the side of the prism.

The little prism is turned by a small piece of watch-work, but it is not at all necessary that this should be exact, since all we demand is that the rate shall be constant during a second or so—a condition easily secured with the most ordinary mechanism.

The sketch and the apparatus exhibited sufficiently indicate, I think, the simple means by which this is brought about.

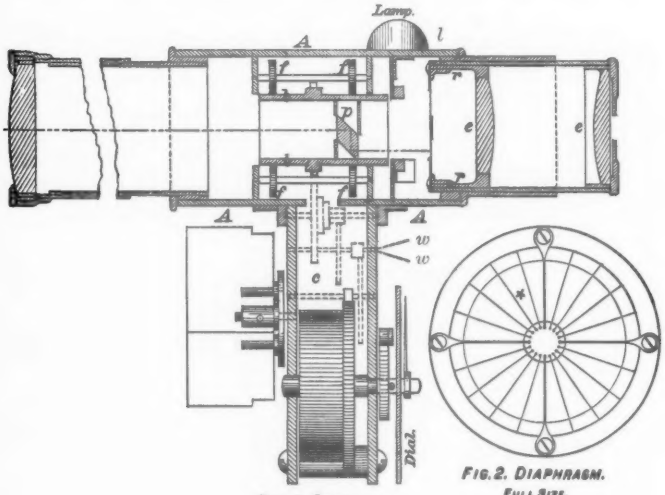


FIG. 1. SECTION.
½ FULL SIZE

FIG. 2. DIAPHRAGM.
FULL SIZE.

S. P. LANGLEY. INVT

Figure 1 is a section one-half full size. A A is the outer tube, which can be fitted, if desired, into the eye end of a tele-

scope. *b b* is the inner tube, resting on friction wheels *f f*, revolved by the clock-work *c c* about once a second, and recording the time at which a key in the observer's hand may be pressed to indicate the particular second. This record may be made electrically by the wires *w w* on a chronograph, or more simply and directly on a little attached dial like that of a recording stop-watch.

p p is the prism of double total reflection, *r r* is the position of the fixed reticule (shown independently as it appears to the observer and of full size in figure 2).

e e are the lenses of a positive eye-piece. The lamp is for giving wire illumination, if desired, when a telescope is employed.

Field illumination is readily obtained otherwise by making the diaphragm in which the prism *p p* is set of translucent material.

Finally it should be remarked that on removing the eye-piece events may be observed without using any telescope. In this, its simplest form, the chronograph may also be dispensed with, and the record of the second made on an attached stop-watch dial and the instrument may thus carry its own complete recording apparatus and be more portable than an ordinary opera-glass.

I have not found opportunity to use this apparatus on the moon or occultations, but I have, what is possibly more to the purpose now, tried it on an artificial star, the instant of whose appearance and disappearance was independently recorded on a chronograph by an electrical contact. Different observers, entirely unskilled and ignorant in the use of the instrument, were invited to look into it and to determine the quadrant and section in which the star appeared and disappeared.

I have momentarily mislaid my notes containing in full detail the results of four observers but I can summarize them approximately by saying that after being simply told what to note; the average probable error (that is, for any single observation) was rather less than one-twentieth of a second. As far as I can judge from the limited number of instances, the younger the observer the better the observation. The worst of the observers (the oldest), however, had a probable error considerably less than one-tenth of a second; the youngest, a probable error of something like one-fortieth of a second, which implies, as you will observe, that he not only readily noted the quadrant and the subdivisions of the quadrant, but, also as a rule, even the part of the subdivision in which the star was first seen. None of these observers had so much as one hour's practice.

The plan in question is easily adapted to meridian observations, but for these we have numerous plans for correcting personal equation, and the writer may also direct attention to the fact of the existence of a distinct device (this Journal, July, 1877) which practically eliminates the personal error in the very act of a transit observation. It is more elaborate than the present one, which is so simple that it may be useful even in longitude work with the transit, though its proper field seems to be the observation of sudden events; but, to whatever purpose it is applied, I beg leave to present it to your attention less for any interest that attaches to the particular mechanism exhibited than as an illustration of a principle which seems to me to have not been employed before, at least in this way, and which I trust may have useful applications.

ART. XII.—*A Spectro-photometric Comparison of Sources of Artificial Illumination;** by EDWARD L. NICHOLS and WILLIAM S. FRANKLIN.

[Contributions from the Physical Laboratory of Cornell University, No. 5.]

IN the comparison of the various sources of light available for the purposes of artificial illumination, the question of color, though scarcely less important than that of intensity, has been very generally disregarded.

The neglect of this factor has doubtless been due in great part to the fact that differences of color are not so easily determined as mere variations in candle power. Progress in this domain involves the study of the distribution of energy in the spectrum, and since it is with the visible wave-lengths that we have to do, often under exceedingly small intensities, the superiority of the eye in sensitiveness over any device for the direct measurement of the energy of the rays in question, dictates in many cases the choice of an optical method.

The experiments to be described in this paper were made in the Physical Laboratory of Cornell University during the summer of 1888. They consisted in the spectro-photometric comparison of various artificial sources of light, and of daylight, with that emitted by a sixteen candle-power incandescent lamp. The sources of light subjected to measurement were:

1. a standard candle;
2. various petroleum flames;

* Paper read at the Cleveland meeting of the American Association for the Advancement of Science, August, 1888.

3. various illuminating-gas flames;
4. a lime-light.
5. electric arc-lights of the two prevailing commercial types (long-arc and short-arc);
6. daylight by clear and by clouded sky;
7. an incandescent lamp of high resistance, at various temperatures;
8. an incandescent lamp of low resistance, at normal candle-power.

The spectro-photometer employed in these measurements was of the type already described in the pages of this Journal.* For the comparison-flame usually employed, we substituted however a sixteen-candle Edison lamp, maintained constantly at its normal voltage.

The rays from this lamp, having been rendered parallel by means of a lens of four inches aperture and short focal length, were passed through two Nicol's prisms, the first of which was free to revolve, before entering the total-reflection prisms at the slit of the spectroscope. This comparison lamp was placed at the observer's right hand, the axis of the condensing lens and of the Nicol's prisms being at right angles with the collimator tube and in the same vertical plane as the slit. The light to be compared was introduced into the collimator tube from the opposite side, by means of a similar pair of total reflection prisms. The arrangement of these four prisms has been described in the article last cited.

One of the chief sources of error in the comparison of various illuminants, lies in the great range of temperature in the glowing material which constitutes the source of light. Each element of the radiating surface adds its quota to the general illumination, and it is impossible to find any single region, the spectrum of which is identical with that of the entire source. We met this difficulty by allowing the light under observation to fall upon the face of a block of magnesium carbonate, taking the spectrum of the rays reflected by the latter. Magnesium carbonate is not a pure white,† but it reflects all the wave-lengths of the visible spectrum in sufficient quantity for the purpose in question.

Ten regions of the visible spectrum were selected for measurement, and the intensity of the spectrum of an Edison incandescent lamp, giving 16 candles at 100 volts, was taken as the unit of comparison for each region. All other spectra were reduced to unit intensity in the region of the D line,

* This Journal, vol. xxxvi, p. 332.

† See E. L. Nichols, "On Black and White," Transactions of the Kansas Academy of Science, vol. x.

their brightness in other regions being expressed in terms of that of the corresponding wave-length of this standard spectrum. This method of presenting the results of spectro-photometric comparisons, seems to us to offer many advantages. It was adopted by Mr. W. H. Pickering in an investigation made some years since, and covering very much the same ground as our own;* and although other wave-lengths have been selected by some writers, for instance that of a certain region in the green (λ=5570) which Otto Schumann has taken as unit of brightness in his recent study of the spectrum of the incandescent lamp, there seems to be no good reason for abandoning the region of the D line, as a reference point, in favor of any other portion of the spectrum.

Candles, Oil and Gas.

Measurements were first made upon two standard candles burning side by side in a double holder designed for use in the Bunsen photometer. Every one who has had experience with this light in photometry is aware that the candle is very far from being a constant source of illumination. Pickering in the paper already cited has expressed the opinion that, "of all the artificial lights examined . . . none was so uncertain in color as the standard candle." We concluded from the consideration of many widely fluctuating values, taken in various parts of the spectrum, that the color of the candle, under the most favorable conditions of combustion, was very nearly the same as that of the 16-candle lamp used as a standard in our measurements, but that its average color was decidedly redder than that of the incandescent lamp.

Experiments upon various petroleum and gas flames showed that these also were of very nearly the same color as the incandescent lamp. Nearly all of them were subject to slight fluctuations in color and intensity, due to variations in the conditions of combustion which were beyond control. These fluctuations, although much less marked than in the case of the candle, were sufficient to cause changes of color greater than the average difference of color between the flame under investigation and the incandescent lamp. One of the gas flames subjected to measurement, that of a lamp of the type known as the "board of trade" argand, a sixteen-candle standard constructed especially for photometric work, was however of remarkable steadiness both in color and intensity, and measure-

* W. H. Pickering, Photometric Researches; Proceedings of the American Academy of Arts and Sciences, vol. xv, 1880.

ments throughout its spectrum showed the quality of its light to be identical with that of our standard incandescent lamp.

It appears then, that the temperature of the carbon filament in the glow lamp of to-day, when heated to the highest degree of incandescence compatible with permanence, agrees very closely with that reached by the light-giving particles of oil and gas flames when the latter are maintained under the conditions of combustion most favorable to the production of light.

The Lime Light.

The source of illumination to which our attention was next directed, was a lime-light of the type used in the magic lantern. The oxy-hydrogen flame by means of which the lime cylinder was maintained in incandescence, was fed by oxygen and hydrogen gas obtained by electrolysis. The gas was drawn from large storage reservoirs under constant pressure and neither burner nor cylinder was readjusted during the time occupied by a complete set of observations. It was found that the lime reached its highest temperature very soon after ignition and then fell rapidly in brightness to an almost constant condition, in which it could be maintained without further marked change for a considerable length of time.

During this first period of incandescence the lime-light is very much whiter than in the permanent condition into which it soon sinks. Its color indeed approaches very closely to that of burning magnesium. Table I gives the results of a single set of observations upon the freshly ignited lime, comprising the mean of three readings in each of nine regions of the spectrum. The mean of several complete sets of observations upon the lime when it had reached its permanent state of incandescence are also given, and these last results are compared with those obtained by Pickering by measurement of the spectrum of a similar source of light.

In these and the following tables the intensity of each region is given in terms of the brightness of the corresponding region in the spectrum of the 16-candle incandescent lamp selected as a standard; the region of the D line in both spectra being taken as unity. The four regions studied by Pickering do not coincide in wave-length with those selected by us, nor was his standard of comparison an incandescent lamp. The wave-lengths of his positions and the brightness of his standard in those positions, as compared with that of a gas flame, are given in his paper. Now the color of an argand gas flame does not differ materially from that of our standard, and it is therefore a simple matter to bring his observations and our own into direct comparison.

TABLE I (Lime-light.)

Region of the Spectrum.	Lime freshly ignited.	Lime in final state of incandescence.	
	Lime-light / Standard lamp.	Lime-light / Standard lamp.	Lime-light / Gas-light. (Reduced from observations of W. H. Pickering.)
λ=7530	0·65	0·49	----
6685	0·76	0·72	----
6562	----	----	0·76
6080	0·89	0·89	----
5890	1·00	1·00	1·00
5570	1·24	1·18	----
5185	2·10	1·32	----
5180	----	----	1·10
4920	3·84	1·62	----
4685	5·38	1·81	----
4500	10·80	2·08	2·28

It will be seen that the lime-light, in its final condition is relatively twice as bright in the violet (λ=4500), and relatively one-half as bright in the extreme red (λ=7530) as an argand gas flame or the standard incandescent lamp. The comparison of our results with those of Pickering is of interest because of the evidence it affords that the quality of the lime-light remains nearly constant under presumably very different conditions. The two sets of results were obtained by entirely different methods. Pickering used a diffraction grating and brought the spectra under observation to equal brightness by varying the distance of the standard lamp from the slit. His standard consisted of a portion of a gas flame which was decidedly redder than the same flame taken as a whole. We used a glass prism, brought the two spectra to equal brightness by means of a pair of Nicol's prisms and adopted a standard which was relatively about three-fourths as bright in the red and five-fourths as bright in the violet as Pickering's standard.

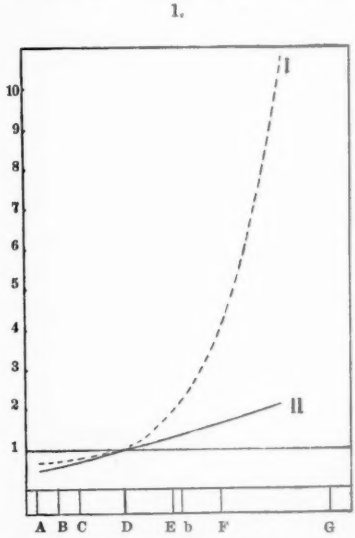


Figure 1. Curves of relative intensities in the spectrum of the lime-light. Curve I, gives results of measurements upon the freshly ignited lime. Curve II, upon lime in permanent state of incandescence.

We shall have further occasion presently to compare these two methods, and to place the results side by side with those obtained by the use of still other forms of photometer.

The Light of the Electric Arc.

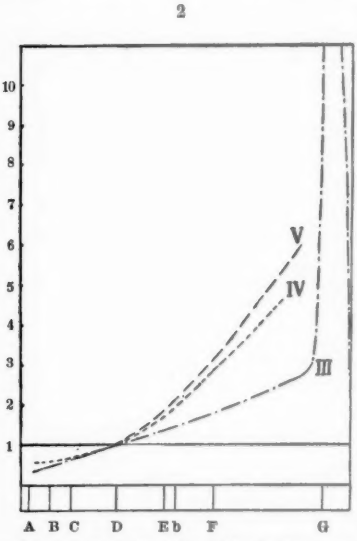
Our experiments with the arc-light were made for the most part upon a lamp of the "long-arc" type, with about 10 amperes of current and 50 volts. The lamp was suspended at a distance of 70^{cm} from the block of magnesium-carbonate. It could be raised or lowered at will, so as to expose the latter to the rays emitted in the horizontal plane, or at angles above or below the same. A lens placed near the lamp threw an enlarged image of the carbons upon a screen carrying a vertical scale, so that the length of the arc could be determined at a glance.

Measurements were made with the magnesium-carbonate in the horizontal plane with the arc, and at positions 16° above, and 14°, 28° and 50°, respectively, below that plane. The carbons used in the lamp were $1{\cdot}2^{cm}$ in diameter. They were of the commercial brand known as the "Faraday carbon," and were copper plated.

The observations made upon rays given off in the horizontal plane and in directions below the horizon, viz: in the three last named positions above mentioned, showed that although the quantity of light increased rapidly from the horizontal plane downward, reaching a maximum in the neighborhood of 50°, as in all arc-lamps of the type in question, the quality of the light was very nearly constant throughout that entire zone. The variations in color with change of angle were indeed very much less than those due to the fluctuations occurring during a single set of readings in a single position. Just above the horizontal plane, however, there occurred a quite abrupt and very marked change in the color of the rays emanating from the arc, and the light became much bluer than that within the zone below the horizon.

This change of color, which was apparent to the unaided eye, was found to be due chiefly to the increased brightness of the wave-lengths lying beyond the E line; the distribution of intensities in the red, and yellow being nearly the same in the spectrum of the rays falling below the horizontal plane and in that of the light 16° above the horizon. The manner in which the relative brightness of the spectrum increases toward the violet is best seen by an inspection of curves III and IV, fig. 2, in which these results are exhibited.

During these measurements the current, potential and length of arc were very nearly constant. We found, however, that they might be varied through the widest limits compatible with the maintenance of the arc, without appreciably changing the character of those portions of the spectrum which were under observation. The length of arc was reduced from $3{\cdot}5^{mm}$ to $1{\cdot}^{mm}$, the shortest arc which the lamp in question could be made to sustain, without introducing any change in the distribution of intensities; and a "short-arc" lamp using the same carbons, with 21 amperes, $27{\cdot}^{*}$ volts and an arc too short to be measured, gave almost precisely the same values throughout the spectrum as those obtained from the long arc lamp. (See Table II.)



Curves of relative intensities in the spectrum of the electric arc. Curve III is from measurements below the horizontal plane, curve IV from measurements above the horizontal plane (16°), curve V is from Vogel's measurements of the Foucault regulator.

A study of the spectrum of the arc-light which included only the regions lying between $\lambda=7530$ and $\lambda=4500$, would, however, be incomplete and misleading. Our measurements of that part of the spectrum show, as will be seen by an inspection of Table II and the curves already referred to, that the distribution of energy between the above mentioned limits is very similar to that in the spectrum of the lime-light. The latter is slightly stronger in the red and weaker in the violet than the arc-light, but the difference is not sufficient to account for the much greater brilliancy of color in the electric-light, nor for its higher actinic value. The source of the difference in character, and also of the well known excess of violet light in the "long-arc," as compared with the "short-arc" light, is to be found, however, for the most part among still shorter wave-lengths. The electric arc possesses an extremely brilliant band, really of complex structure, but apparently continuous under the conditions of observation with which we have to deal here, having its maximum in the neighborhood of wave-length 4280 and entirely embraced within the region lying between $\lambda=4320$ and $\lambda=4250$.

Special measurements of the "long-arc" lamp were made to include this violet band. No break in the curve of intensities was found until the edge of the band was reached, the relative brightness at $\lambda=4330$ being scarcely three times that of the standard. From this point it rose at once to more than twenty times that of the standard, a quantity approximating to that of daylight in the same region. Beyond $\lambda=4250$ the values fell again into the continuation of the original curve. The results of these measurements are also given in Table II and curve III, figure 2.

TABLE II (*the Electric Arc*).

Wave-lengths.	Short-arc 21 amperes 27·5 volts $a=30°$.† Electric arc	Long-arc* (10·5 amperes, 52 volts).	
		Below the horizon. Electric arc‡	Above the horizon. $a=-16°$.† Electric arc
	Standard lamp.	Standard lamp.	Standard lamp.
7530	8·50	0·36	0·55
6680	0·71	0·55	0·66
6080	0·88	0·90	----
5890	1·00	1·00	1·00
5570	1·26	1·26	----
5185	----	1·63	1·96
4920	----	1·73	2·85
4685	2·08	2·03	3·88
4500	2·50	2·51	4·64
4340	----	2·80	----
4250	----	20·40	----
4100	----	3·22	----

The results of measurements of the light from the "Foucault regulator" arc-lamp, by A. Crova,§ W. H. Pickering‖ and H. C. Vogel,¶ reduced to a common scale for purposes of comparison, are incorporated in Table III. Crova's standard of comparison was a moderator lamp burning colza oil, concerning the color of the flame of which we only know that it was slightly redder than that of the stearine candle. The set of values given in Table III, are obtained from his measurements without taking into consideration the quality of his standard lamp. They are between those of Pickering and Vogel.

None of these determinations take cognizance of the violet band at λ 4280. They are introduced here because they afford a comparison of the results of three distinct methods of spectro-

* Length of arc $=3·5^{mm}$.

† a is the angle which the line, joining the block of magnesium carbonate with the arc, makes with the horizontal plane.

‡ Mean of values for $a=0°$, $a=14°$, $a=28°$ and $a=50°$.

§ A. Crova, Comptes Rendus, t. lxxxvii, p. 322, 1878.

‖ W. H. Pickering, Photometric Researches, etc., p. 246.

¶ H. C. Vogel, Berliner Monatsberichte, 1880; p. 801.

photometry, as applied to so difficult an object as the arc-light, concerning which Vogel, whose measurements of this source of light, and of sunlight, daylight, and the light of the moon and of various fixed stars, are of uncommon accuracy, makes note that the limit of accuracy of his determinations of the electric light is about 16 per cent.

TABLE III.

A comparison of various measurements of the spectrum of the Foucault regulator.

Wave-lengths. λ	From measurements by A. Crova. Arc-light / Colza oil light.	From measurements by W. H. Pickering. Arc-light / Gas light.	From measurements by H. C. Vogel. Arc-light / Petroleum.
6760	0·59	----	----
6562	----	0·82	----
6333	----	----	0·71
6050	0·94	----	----
6000	----	----	0·88
5890	1·00	1·00	1·00
5600	1·19	----	----
5550	----	----	1·33
5230	1·76	----	----
5180	----	1·17	----
5170	----	----	2·08
4860	2·27	----	3·11
4640	----	----	4·16
4590	4·97	----	----
4550	----	5·88	----
4440	----	----	5·33
4260	----	----	6·66

These values, taken in comparison with those given in Table II, afford us abundant evidence that the light of arc-lamps with small carbons is very much whiter than that emanating from the large commercial lamps of the present day, with carbons of half inch diameter. This conclusion is quite in accordance with the results of recent investigations of the economy of the arc-light, in which it has been shown that the candle-power increases with the current-density.* Certain experiments upon the ratio between total radiation and luminous radiation from the electric arc, now in progress in the Physical Laboratory, point unmistakably to the same conclusion.

Daylight.

The method pursued in the determination of the color of daylight, was in every respect similar to that employed in the study of the lime and arc-lights. The rays falling upon

* Schreihage (La Lumiere Electrique, xxix, p. 585), has shown that the result of diminishing the cross section of the carbons of an arc-lamp from 254^{dmm} to 40^{dmm} was to increase the mean spherical candle-power from 161 candles to 471 candles, with corresponding increase in the efficiency of the lamp.

the block of magnesium carbonate were admitted through a four inch aperture in the opaque shutter which otherwise completely closed the only window of the spectrometer room. This window had a southerly exposure and the light reaching the magnesium-carbonate was received almost exclusively from the sky. Of the considerable number of comparisons which we made on different days, only two are presented in Table IV. One of these was made between two and three P. M. on a cloudless day of the summer of 1888, the other on the day following, when the sky was completely overcast with very heavy, dark, low-hanging clouds. Our other measurements all gave values lying between these extremes and, since they show no peculiarities which are not better exhibited by the latter, they have been omitted from the table.

Comparisons of daylight with artificial sources of illumination have likewise been made by O. E. Meyer * and H. C. Vogel,† and similar comparisons of the direct rays of the sun by Crova,† Meyer, Pickering, § Vogel, G. Müller, ‖ F. Exner ¶ and others.

The results given in Table IV, where our own measurements are placed side by side with those of Vogel, reduced to the same scale, exhibit in the most striking manner the enormous richness of daylight, as compared with any form of artificial light, in the shorter wave-lengths. In the extreme violet, (λ=4440 and 4260), according to the measurements of Vogel, day light by unclouded sky is relatively fifty and one hundred times brighter than a petroleum flame. Scarcely less surprising is the difference in quality between the daylight of clear and cloudy weather. The absorption due to moisture in the latter case begins to be important in the neighborhood of the F line, from which point it increases rapidly in amount to the end of the visible spectrum. Our curve of intensities for clear weather (see figure 3, curve VI) shows traces of this same absorption in the violet.

All the European observers, with the exception of O. E. Meyer, whose measurements of the electric arc and of day light and sunlight are widely at variance with those to which reference has been made, agree in finding the absorption of the shorter wave-lengths even more marked in the direct rays of the sun than in daylight by clouded sky. Thus Vogel, whose measurements may be taken as typical, gives for sun light the following values, which have been reduced to the same scale as those presented in Table IV.

* O. E. Meyer, Carl's Zeitschrift für Angewandte Elektricitäts-lehre, I, p. 320, 1879. † H. C. Vogel, l. c. ‡ A. Crova, l. c.
§ W. H. Pickering, Photometric Researches, etc., p. 246.
‖ G. Müller, Astronomische Nachrichten, ciii, p. 241, 1882.
¶ F. Exner, Repertorium der Physik, xxii, p. 605, 1886.

TABLE IV.

Daylight by clear and by clouded sky, compared with the light of a 16-candle incandescent lamp.

Sky Cloudless.				Sky Overcast.			
Measurements of H. C. Vogel (Reduced).		Measurements of Nichols and Franklin.		Measurements of H. C. Vogel. (Reduced).		Measurements of Nichols and Franklin.	
Wave-lengths.	Daylight / Petroleum.	Wave-lengths.	Daylight / Standard.	Wave-lengths.	Daylight / Petroleum.	Wave-lengths.	Daylight / Standard.
6330	0·50	6685	0·32	----	----	7530	0·13
6000	0·79	6080	0·75	6330	0·52	6685	0·45
5890	1·00	5890	1·00	600	0·84	6080	0·90
5550	2·00	5570	1·69	5890	1·00	5890	1·00
5170	5·00	5185	4·19	5550	1·78	5570	1·50
4860	10·52	4920	7·33	5170	3·80	5185	2·79
4640	22·22	4685	16·79	4860	7·77	4920	4·59
----	----	4500	21·37	4640	13·74	4685	6·45
4440	50·00	----	----	----	----	4500	9 08
4260	100·00	----	----	4440	17·80	----	
				4260	19·84	----	

TABLE V.

Sunlight, compared with a petroleum flame (reduced from the measurements of H. C. Vogel).

Wave-lengths.	Sunlight. / Petroleum flame.
6330	0·57
6000	0·75
5890	1·00
5550	1·31
5170	2·53
4860	4·87
4640	7·30
4440	11·93
4260	13·16

The only American observer, Mr. W. H. Pickering, has, however, obtained values for the relative brightness of the sun's rays which agree very closely indeed with those for day-light by unclouded sky, as observed by Vogel and by ourselves. Thus Pickering finds for the violet

$$\lambda=4550\,;\ \frac{\text{Sunlight}}{\text{Gaslight}}=23\cdot77 \text{ (reduced).}$$

Our value for the same region (see table IV), is,

$$\lambda=4500;\ \frac{\text{Daylight}}{\text{Standard}}=21\cdot37$$

Vogel's result, in nearly the same portion of the spectrum is,

$$\lambda=4640\,;\ \frac{\text{Daylight}}{\text{Petroleum flame}}=22\cdot22 \text{ (reduced).}$$

These values have been brought to a common scale, as in all former comparisons, the region of the D line in both spectra being taken as unity.

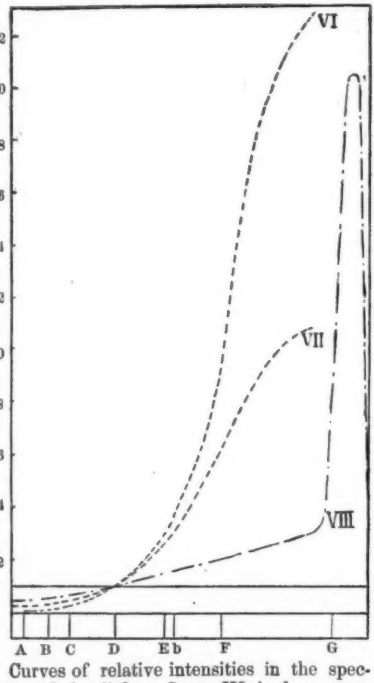
It would not seem unreasonable to ascribe the difference in question, to the atmospheric conditions under which the observations were made.

The Incandescent Lamp.

Our study of the incandescent lamp included the comparison of lamps of high and low resistance, heated to normal candle-power, and determinations of the color of the former in different stages of incandescence. The lamps in question were the Edison lamp which had been used as a standard throughout our investigation and a Bernstein lamp giving 16 candles at 20 volts.

The results, which are given in table VI (see also figure 4), show that the temperature of the lamp of low voltage was not so high as that of the Edison lamp at the same candle-power, and that the spectrum of the former was correspondingly of greater relative brightness in the red than in the violet.

3.



Curves of relative intensities in the spectrum of day-light. Curve VI is from measurement of day-light by unclouded sky, curve VII of day-light by heavily clouded sky. Curve VIII, introduced for comparison is same as curve III, figure 2, and represents the spectrum of the electric-arc. The horizontal line represents the spectrum of the standard incandescent lamp.

Previous to the detailed study of the Edison lamp, the lamp was placed in the Bunsen photometer and the relation between electromotive force and candle-power determined for a range of brightness between 1 candle and 30 candles. It was then maintained successively at potentials corresponding to 4 candles, 10 candles, 16 candles, 22 candles and 28 candles, and its spectrum

in each of those stages of incandescence was measured by the method already described.

TABLE VI.

Comparison of a Bernstein incandescent lamp at the same candle-power.

Wave-lengths.	Bernstein lamp. / Standard lamp.
7530	1·19
6680	1·08
6080	1·03
5570	0·97
5185	0·93
4920	0·91
4685	0·89
4500	0·87
4340	0·85

The results of these determinations are given in Table VII (see also figure 5). The brightness of the spectrum of the lamp at 16 candles is taken as unity throughout, and the intensity of the spectrum at other candle-powers is expressed in terms of the brightness of the corresponding region of the former.

TABLE VII.

An Edison lamp at various degrees of incandescence, compared with the same lamp at 16 candle-power.

Wave-lengths.	Intensity at 4 candles. / Intensity at 16 candles.	Intensity at 10 candles. / Intensity at 16 candles.	Intensity at 16 candles. / Intensity at 16 candles.	Intensity at 22 candles. / Intensity at 16 candles.	Intensity at 28 candles. / Intensity at 16 candles.
7530	0·34	0·71	1·00	1·18	1·56
6680	0·28	0·63	1·00	1·29	1·71
6080	0·23	0·58	1·00	1·34	1·80
5890			1·00		
5570	0·22	0·55	1·00	1·37	1·89
5185	0·19	0·53	1·00	1·38	1·97
4920	0·17	0·52	1·00	1·38	2·04
4685	0·16	0·51	1·00	1·39	2·12
4500	0·15	0·51	1·00	1·39	2·18
4340	0·14	0·51	1·00	1·39	2·24

This method of presentation enables us, by inspection of the table and curves, to see at a glance the changes which take place in the spectrum of the lamp as the candle-power is increased. With rising temperature the change is least in the extreme red, the rate of change increasing rapidly as we approach the violet end of the spectrum.

Thus the brightness of the spectrum in the neighborhood of the A line, when the lamp is raised from 4 candles to 28 can-

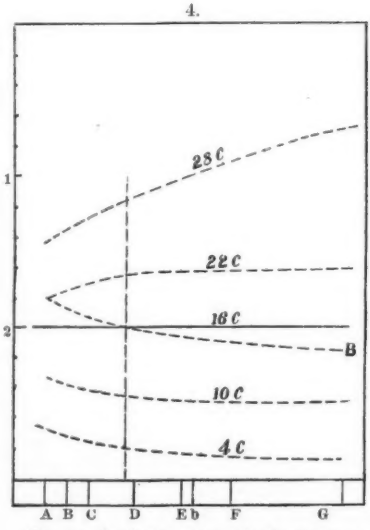
dles, increases very nearly in the ratio 1 : 3·7; whereas the corresponding ratio for the neighborhood of the G line is approximately 1 : 22; intermediate regions giving values lying between these limits. In the yellow, (region represented by $\lambda = 6000$), this ratio has a value which is identical with that which expresses the change of candle-power.

In all regions toward the red from this particular wave-length, the brightness of the spectrum increases less rapidly, in all regions of shorter wave-length it increases more rapidly than the candle-power.

The position of this region, in which the brightness of the spectrum increases in direct proportion to the candle-power, is indicated in figure 4, by a vertical line.

It lies slightly toward the red from the position of maximum luminosity in the spectrum of the incandescent lamp, as determined for a lamp of the same type by Otto Schumann.*

The location of this line is of especial interest because of the light it throws upon the results obtained with the Bunsen photometer when that instrument is applied to the comparison of sources of light differing in composition. The line in question does not divide the spectrum equally either in respect to the total energy of luminous radiation of the portions lying between it and the red on the one side and between it and the violet on the other, nor in respect to the total luminosity of those portions.



Curves of relative intensities in the spectrum of the incandescent lamp. Curves marked 4*c*, 10*c*, 16*c*, 22*c*, 28*c*, refer to the standard incandescent lamp at various temperatures. Curve B refers to a low voltage lamp at normal candle-power.

Suppose the case of four incandescent lamps, so constructed that when they give 16 candles each, their temperatures are respectively those of the Edison lamp upon which our measurements were made, when the latter gives 4, 10, 22 and 28 candles.

As measured in the Bunsen photometer these lamps would be found of equal candle-power, but they would differ greatly

* Otto Schumann, Elektrotechnische Zeitschrift, v, p. 220.

in color and the spectro-photometric examination of their spectra would give us a set of curves corresponding in character to those shown in figure 4. These spectra would be of the same brightness in the yellow ($\lambda=6000$), but at no other point within the limits of the visible spectrum. The lamps would differ in total energy of radiation, in the energy represented by their light-producing rays, and in total luminosity. With increasing incandescence the total energy of the regions lying beyond wave-length 6000, and also their luminosity, increase rapidly; and the corresponding decrease in regions between that wave-length and the red end of the spectrum is not sufficient to keep the energy and luminosity of the whole visible spectrum constant. It follows, therefore, that candle-power, as determined by means of the Bunsen photometer, affords us a correct measure neither of the light-giving energy nor of the luminosity of the source of light; the direction of the error always being such as to favor sources of a low degree of incandescence when compared with those of higher temperature.

The discrepancy between candle-power and luminosity, with increasing incandescence, is less marked than that between candle-power and energy of radiation, because luminosity depends very largely upon the less refrangible rays of the spectrum. Schumann's admirable study of the color and brightness of the incandescent lamp, to which reference has already been made, affords data for a comparison of candle-power and total luminosity of this source of light, luminosity being determined according to the method of Macé de Lepinay. Calculations based upon his measurements show that when the incandescence of a glow lamp is raised from 10 candles to 50 candles, its luminosity is increased in the ratio of 6:1 instead of 5:1. For light emanating from sources of higher temperature the discrepancy is still more marked. In the case of the electric-arc light, for example, the ratio of luminosity to candle-power is approximately 5:4 and in the case of day light it is probably commonly in excess of 6:4.

Every improvement, therefore in our methods of artificial lighting which makes it possible to raise the temperature of incandescence of the illuminant will be accompanied by a double gain. On the one hand a greater candle-power per unit of energy expended will be obtained, and on the other hand, the light-giving value per candle-power will be increased.

Every such step will render our present method of reference to the standard candle as a unit less satisfactory, and the time is probably not far distant when we shall have learned to measure the temperature of our illuminants and to express their light-giving value in terms of the temperature of the glowing material and the area of the illuminating surface.

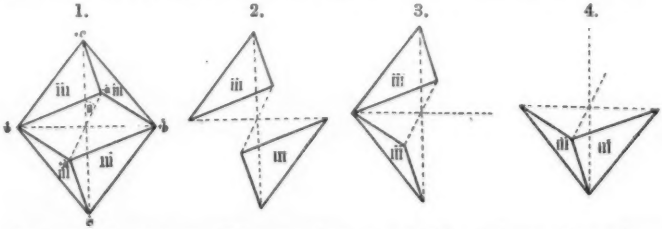
ART. XIII.—*On the possibility of Hemihedrism in the Monoclinic Crystal System, with especial reference to the Hemihedrism of Pyroxene;* by GEORGE H. WILLIAMS.

IN a recent "Note on some remarkable Crystals of Pyroxene from Orange Co., N. Y.,* I described an unusual monoclinic habit of this mineral which showed the planes of different forms grouped about opposite extremities of the vertical axis. These crystals were then called hemimorphic with reference to the vertical axis, although it was recognized that such an expression did not accord strictly with the accepted nomenclature, because in the monoclinic system the vertical axis is not an axis of symmetry.

During the past summer it was suggested to me by Professor Rosenbusch that these crystals might possibly be regarded as hemihedral rather than hemimorphic, and such upon more mature consideration appears to be the case. I therefore venture to refer once more to the Orange Co. crystals, both because their apparently anomalous form receives a new interest when viewed in this light, and also because they have been found, upon further investigation, to offer by no means an isolated instance of this peculiar development in pyroxene.

As they are at present used in crystallography, the terms *hemihedrism* and *hemimorphism* both express the independent occurrence of one-half of the planes belonging to a crystalline form. They differ, however, in the manner in which these planes are grouped; the former representing half the planes as occurring equally about both extremities of an axis of symmetry, while the latter implies the presence of all the planes of a form at one end of such an axis, and none of them at the other.

The most general holohedral form consistent with the symmetry of the monoclinic system is a hemipyramid (±P), composed of four planes, one in each of the four similar octants.



It is evidently possible to select one-half of these four planes in three and only three different ways:

* This Journal, III, xxxiv, pp. 275–276, Oct., 1887.

1. We may select two planes which are parallel $(\bar{1}\bar{1}1)$ and $(11\bar{1})$; and, if the other pair of parallel planes, $(1\bar{1}\bar{1})$ and $(\bar{1}11)$ disappear, there results a tetrapyramid composed of two planes, which is the most general form possible in the triclinic system (fig. 2). Such a form would be truly hemihedral because the planes are similarly grouped about each extremity of the axis of symmetry. A combination of such forms similarly developed would not, however, differ from a triclinic combination and this system may therefore be regarded as a kind of monoclinic hemihedrism. Orthoclase is sometimes quoted as an instance of this triclinic hemihedrism because its imperfect prismatic cleavage is often developed parallel to only one face of the prism. This was first noticed by Haüy and has been substantiated by many subsequent observers.

2. We may select the two planes which meet at an end of the axis of symmetry, $\bar{b}$, $(\bar{1}\bar{1}1)$ and $(1\bar{1}\bar{1})$. If the corresponding pair, $(\bar{1}11)$ and $(11\bar{1})$ should disappear (fig. 3) there would result, as Groth remarks,* not a hemihedral, but a hemimorphic form. By this method of selection those holohedral forms belonging to the orthodiagonal zone must remain unaltered, while all others, including the clinopinacoid, may occur with only half of their planes developed. The plane of symmetry here disappears as in the preceding case.

This case is illustrated by the crystals of several organic compounds, among which are tartaric acid ($C_4H_6O_6$),† cane sugar (sucrose, $C_{12}O_{22}H_{11}$)‡ and quercite (pentacid alcohol, $C_6H_{12}O_5$).§ These crystals have furthermore all been shown to be pyroelectric—a property which is especially characteristic of hemimorphic substances.

3. We may, as a last possibility, select two of the planes of the monoclinic hemipyramid which intersect in the plane of symmetry, $(1\bar{1}\bar{1})$ and $(11\bar{1})$. If the corresponding pair, $(\bar{1}\bar{1}1)$ and $(\bar{1}11)$, disappear (fig. 4) there results an apparent hemimorphism with reference to either or both of the axes in the plane of symmetry—vertical or clinodiagonal. The only holohedral form which cannot appear with only half its planes by this method of selection is the clinopinacoid. All others may be present with only half their planes, although of course both halves of a form may appear on the same crystal. If this be the case in the vertical zone there results apparent hemi-

* Physikalische Krystallographie, 2d Ed., p. 481. 1885.

† De la Provostaye, Ann. Ch. et Phys., III, vol. iii, p. 139. 1841.

‡ Wulff, Jour. für prakt. Chemie, vol. xxviii, p. 129, 1843. L. Wulff, in his recent article on the crystallization of cane-sugar (Zeitschr. für Kryst., vol. xiv, pp. 552–562, 1888), finds that the face g, $P\bar{\infty}$ (011) generally occurs with only a single plane, which forces him to regard the substance as an instance of either monoclinic tetartohedrism or triclinic hemihedrism.

§ Lewis, Proc. Cryst. Soc., p. 51, 1882: cf. also Groth, Physikalische Krystallographie, 2d Ed., pp. 512 and 514.

morphism with reference to the vertical axis, as shown in figs. 5 to 8. It might, however, be the case that the forms of the clinodiagonal zone were fully developed, when the crystal would appear hemimorphic in the direction of the $\dot{a}$ axis.

This selection of the planes in reality satisfies all the conditions of hemihedrism since its planes are equally distributed about both extremities of the axis of symmetry. The hemihedrism is moreover inclined-faced, because its forms possess no center of symmetry ;* or, in other words, their planes do not have others parallel to them. In this case alone of the three does the monoclinic plane of symmetry remain.

There is therefore possible in the monoclinic system :

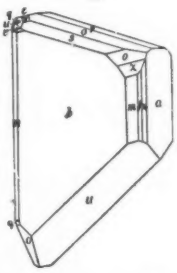
1. Parallel-faced hemihedrism. Triclinic system.
2. Hemimorphism.
3. Inclined-faced hemihedrism.

A similar suggestion has been offered by L. Wulff,† and in his recent paper on the crystallization of cane-sugar the same author has given figures very much like those here presented,‡ although I was not cognizant of his work until this article was ready for publication.

The theoretical possibility of such hemihedral and hemimorphic forms in the monoclinic system has, however, for mineralogists but little interest apart from their actual occurrence in nature. The first two are already well known and recognized ; the third has heretofore lacked recognition on account of the want of examples, and it is the especial object of this paper to show that it is by no means uncommon on such an important mineral as pyroxene, while it may possibly occur on sphene.

The earliest recorded, as well as one of the most remarkable instances of this inclined-face hemihedrism in pyroxene which has come to my notice, is to be found in a perfectly developed crystal of diopside, probably from the Mussa Alp in Piedmont, figured and described by Hessenberg§ in 1856. His figure is here reproduced (fig. 5), drawn so as to show the clinopinacoid as the principal face. Here, as in all other cases, the prismatic zone is holohedral with the forms a, $\infty\breve{P}\infty$ (100) ; b, $\infty\breve{P}\infty$ (010) ; m, ∞P (110) ; f, $\infty P\frac{3}{2}$ (130) ; and χ, $\infty P5$ (150). The hemihedrism manifests itself as an apparent hemimorphism in the direction of the vertical axis, at one end of which are the forms p, $+\breve{P}\infty$ ($\bar{1}01$) ; θ, $+P\frac{3}{2}$

5.



* For an explanation of this term, see Sohncke, Zeitschr. für Kryst., vol. xiv, p. 134, 1888.

† Ibid., vol. xiii, p. 499, 1888.

‡ Ibid., vol. xiv, p. 557, 1888. Pl. XI, figs. 3ª, 3ᵇ and 3ᶜ.

§ Mineralogische Notizen, No. 1. Pl. II, fig. 18.

($\bar{1}33$); *s*, +P ($\bar{1}11$); *o*, +2P ($\bar{2}21$); *λ*, +3P ($\bar{3}31$); *y*, +$\frac{5}{3}$P ($\bar{5}53$); *c*, 0P(001); *e*, P$\breve{\infty}$ (011); *z*, 2P$\breve{\infty}$ (021); *σ*, −$\frac{1}{2}$P (112); *u*, −P(111); and *v*, −2P (221). At the opposite extremity occur only the three forms *u*, *o*, and *λ*. The source of this remarkable crystal is not definitely given. It agrees in all respects with the well-known diopsides from Mussa Alp, except in the matter of attachment.

Inquiry has shown that inclined-faced hemihedrism is not altogether rare among the yellowish white pyroxene crystals from near Warwick, in Orange Co., N. Y. These are usually tabular, parallel to the base, and occur either singly or in groups, imbedded in crystalline limestone. A figure of one of these crystals given by DesCloizeaux,* shows above the forms *c*, *s*, *o*, *e* and *μ*, −2P$\breve{2}$ (211). At the lower end there are present *c*, *u* and *a*, +$\frac{3}{2}$P$\bar{3}$ ($31\bar{2}$).

6.

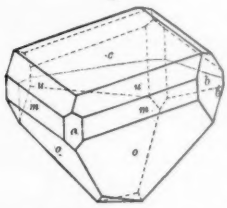
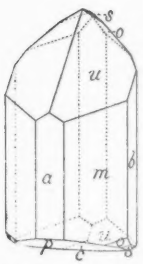


Fig. 6, taken from my above-mentioned "Note," shows a crystal with the usual combination above *c*, *s*, *o* and *u*, while below are the two halves of a crystal in twinning position showing only the two forms *o* and *p*. The crystal was carefully tested for pyro-electricity, but no trace of this property could be discovered even with a delicate Thomson electrometer.

For permission to use the following figure, 7, I am indebted to the U. S. Geological Survey, and also to Professor S. L. Penfield, of New Haven, by whom it was drawn. It represents a perfectly formed pyroxene crystal, 3½ inches in length, from Grassy Lake, near Rossie, St. Lawrence Co., N. Y., upon which the hemihedral distribution of planes is very apparent. At the upper end occur the planes *u*, very large, *s* and *o*. At the lower end are the forms *p*, *c*, *u*, small; *s* and *o*. In the prismatic zone are the pinacoids *a*, *b* and the prism *m*. This crystal was probably formed in calcite, as it is doubly terminated. It was collected by Professor Penfield during the summer of 1888, and is now deposited in the U. S. National Museum at Washington.

7.

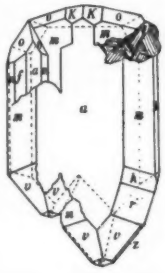


Prof. E. S. Dana has called my attention to the fact that certain of the tabular white pyroxene crystals occurring in the dolomite at Canaan, Conn., also show different forms at opposite extremities of the vertical axis. Indications of such a de-

* Manuel de Minéralogie, vol. i, p. 54. Atlas, fig. 58, 1862.

velopment are apparent on several of these crystals in the Johns Hopkins University mineral collection, but I am indebted to the kindness of Professor Dana for the opportunity of establishing it by an examination of a fine crystal from Canaan, belonging to the Yale University cabinet. This crystal, which is slightly over two inches in length, is represented in fig. 8. Its planes are for the most part broken or uneven from contact with the dolomite and the substance of the crystal is superficially changed to fibrous white hornblende (uralite), which renders measurement with a reflecting goniometer impossible. The size of the crystal, however, allowed of the satisfactory determination of most of the planes with a contact-goniometer. In this way the following forms were identified: prismatic zone: *a*, *f*, *m*, *b*. Upper extremity: *c*, large, *r*, $-\frac{5}{2}$P (552); *o*, K, +mP$\bar{n}$ (?) Lower extremity: *c*, small; *h*, −4P (441); *r*, *v*, *o*, *z*. The following approximate measurements of interfacial angles were obtained with a contact-goniometer, for comparison with which the corresponding values as calculated by von Kokscharow are also given:

8.



c : *r*	back above	126°	125° 26′	*c* : *o*	front above	114°	114° 40′
c : *r*	front below	125½°		*m* : *o*	back below	145½°	144° 36′
a : *r*	back above	133°	133° 24′	*c* : *v*	front below	129½°	130° 5′
a : *r*	front below	133° +		*h* : *m*	"	165° (*ca*)	163° 36′
c : *z*	"	132°	131° 24′	*f* : *m*	"	153½°	152° 52′

The positive hemi-orthopyramid, K, allowed of no definite determination as its planes were small and roughened by the projecting ends of little hornblende needles. It seems, however, to lie in the zone *o* : *o*, and may be the form, +2P$\bar{2}$ ($\bar{2}$11).

It is a striking feature of this crystal that a small portion of its upper half, represented on the left side of the figure, is of quite normal habit, being terminated only by the positive hemi-pyramid, *o*, as is the case below.

The paragenesis of the Canaan crystals is identical with those from Orange Co., N. Y., which are also superficially changed to tremolite. This is a point of some interest, since crystals from both localities show the same hemihedrism in spite of a wide difference in habit.

In a recent conversation with Professor C. W. Brögger, of Stockholm, I also learned that he had not infrequently observed a similar inclined-faced hemihedrism on aegirine crystals occurring in the nepheline rocks of southern Norway.

With such an amount of evidence there can therefore be little doubt that pyroxene illustrates a hemihedrism in the monoclinic system, producing an apparent hemimorphism in the direction of the vertical axis.

Hessenberg's well-known figures of sphene crystals from Rothenkopf in the Zillerthal, Tyrol, exhibit a similar hemihedral development which he at first interpreted as hemimorphism in the direction of the clinodiagonal.* Von Zepharovich, however, subsequently showed that some of these forms could be explained as twins,† and Hessenberg also expressed himself as convinced that even the simplest of these crystals were in reality contact-twins of the ordinary kind where one of the individuals was reduced to an almost invisibly thin lamella.‡

One of Hessenberg's figures is given on p. 385 of Dana's System of Mineralogy (f. 372). I have been permitted through the kindness of Mr. C. S. Bement, of Philadelphia, to examine his fine suite of sphene crystals from the Rothenkopf, which includes the finest crystal ever found there, figured in the Neues Jahrbuch für Min., etc., 1874, p. 828. These all appear to be contact-twins, and it is probable that Hessenberg's second explanation of their apparent hemimorphism or hemihedrism is the correct one. Nevertheless their peculiar habit is of interest in connection with the hemihedral development of pyroxene.

Petrographical Laboratory, Johns Hopkins University,
Baltimore, March, 1889.

ART. XIV.—*On the Earlier Cretaceous Rocks of the Northwestern portion of the Dominion of Canada;* by GEORGE M. DAWSON, Assistant Director Geological Survey of Canada.

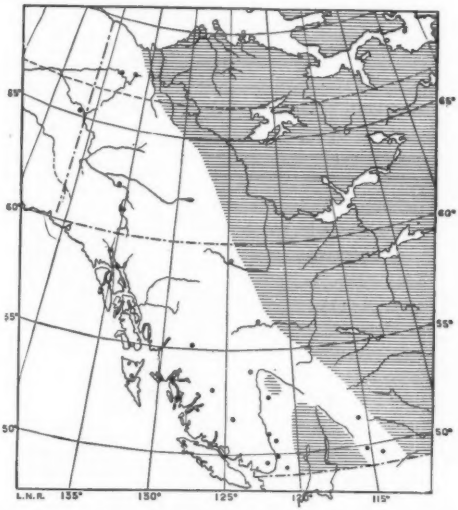
IN the Report of Progress of the Geological Survey of Canada for 1872–73, the late Mr. James Richardson first described an important series of rocks occurring in the Queen Charlotte Islands, which Mr. E. Billings, on paleontological grounds, in an Appendix to the same report, characterized as probably lowest Cretaceous or Upper Jurassic. A further and

* Mineralogische Notizen, No. 6, p. 19, Pl. II. figs. 26–34, 1864. Neues Jahrbuch für Min., etc., 1874, p. 828. If the position of Dana be taken instead of that adopted by Rose and Naumann, as Hessenberg himself allowed to be more rational, these crystals become apparently hemimorphic in the direction of the vertical axis, like pyroxene.

† Sitzungsber. Ak. Wiss. Wien., vol. lx. p. 815, 1869.

‡ Mineralogische Notizen, No. 11, p. 19, Pl. II, figs. 16–18, 1873.

more detailed examination of these rocks, was subsequently made by the writer, of which the results were given in the Report of Progress for 1878–79; and in 1884, Mr. J. F. Whiteaves published a full account of the fossils collected, and reached the conclusion that the series (which is a very thick one) extended from about the horizon of the Gault upward to approximately that of the Lower Chalk.* The name "Queen Charlotte Islands Group" was proposed for the most fossiliferous member of the section (C), and it was further found that no distinct paleontological line could be drawn between this and two underlying members of the section, D and E.† These three lowest subdivisions of the Cretaceous section of the Queen Charlotte Islands, are here therefore referred to collectively, for purposes of description, as the Queen Charlotte Islands formation.



In reporting upon that portion of the Rocky Mountain range proper, which is included between the parallels of latitude of 49° and 51° 30′, the writer described the occurrence there of a very massive earlier Cretaceous formation, holding coals, and characterized by a peculiar flora,‡ which was examined and described by Sir J. Wm. Dawson. These Cretaceous rocks it was proposed to name the Kootanie series or formation.§

* Mesozoic Fossils, vol. i, part 3. † Trans. Royal Soc. Can., vol. i, sec. 4, p. 85.
‡ Annual Report, Geol. Surv. Can., 1885.
§ By Sir J. Wm. Dawson at the annual meeting of the Royal Soc. Can., May, 1885. Science, vol. v, p. 531. Trans. Royal Soc. Can., vol. iii.

The purpose of the present note is to call attention to certain facts recently developed respecting the equivalency of the Queen Charlotte Islands and Kootanie formations and to the importance of the earlier Cretaceous rocks of which they are representatives, over great areas of the western and extreme northwestern portion of the continent. These facts possess particular interest at the present time from their analogy to those lately developed by Mr. R. T. Hill respecting a similar earlier Cretaceous formation in the southwestern region of the United States.*

The region in which the Kootanie was first recognized as a distinct lower portion of the Cretaceous, embracing that portion of the Rocky Mountains above defined, with the adjacent foot-hills, has a length of about 140 miles with a width of forty miles or more. The Kootanie formation here constitutes a great part of the area of the several Cretaceous troughs or infolds and comes to the surface as well in several or many places in the foot-hills to the east. The Cretaceous rocks of this part of the mountains are known to extend upward from the Kootanie so far as to include the base of the Laramie. The thickness of the upper members of the series has not been ascertained, but that of the Benton (possibly including part of the Niobrara) is about 1400 feet, while the maximum known thickness of the lower part of the series, referable to the Dakota and Kootanie, is about 11,950 feet. Of this thickness, over 7000 feet is shown by its fossils to belong to the Kootanie, while the line between this formation and the Dakota remains to be drawn in a series of beds above, from which no fully distinctive fossils have been collected.†

In the report for 1885, above cited, it is stated that one of the characteristic fossil plants of the Kootanie had previously been found in northern British Columbia, at a distance of 580 miles to the northwestward of the part of the Rocky Mountains there under description. The flora of the Kootanie was characterized as Lowest Cretaceous and placed on approximately the same horizon with that of the Queen Charlotte Islands formation (more particularly of subdivision C., of that section) by Sir J. Wm. Dawson.‡

Up to this time no recognizable fossils other than plants had been obtained from the Kootanie, but marine mollusks have since been discovered by Mr. R. G. McConnell in beds which are (at least locally) at the very base of the formation and which underlie the principal plant-bearing beds by at least several hundred feet. These are referred to in Mr. McCon-

* See this Journal, vol. xxxiii, p. 291; vol. xxxiv, p. 287; vol. xxxvii, p. 282.

† Though fossil plants apparently referable to the Dakota have been found in the higher beds, in two places.

‡ Trans. Royal Soc. Can., vol. iii, sec. 4, p. 20.

nell's report,* and the identity stated, on the authority of Mr. Whiteaves, of three forms with species of the Queen Charlotte Islands formation. Mr. Whiteaves' subsequent detailed study of these fossils fully confirms and further carries out the correspondence between the two faunas, as explained by him in a report now in process of publication.† Thus the very important fact is established of the existence of an identical earlier Cretaceous horizon on the West Coast, and in, and even to the east of, the eastern range of the Cordillera System.

Turning now to the portion of the Cordillera region which intervenes between the above-mentioned widely separated localities, including that part of British Columbia to the south of the 56th parallel of latitude, we find there further evidence of the same great earlier Cretaceous formation.—The Iltasyouco beds (probably 10,000 feet in thickness) holding a fauna which was originally regarded as Jurassic, are now definitely referred to the Queen Charlotte Islands formation.‡ Further, the association of *Aucella Mosquensis*, var. *concentrica*, with the fossils of the last-mentioned formation in its typical locality, with the recent discovery by the writer of the same form, in great abundance, in beds of identical age in the northern part of Vancouver Island, leads Mr. Whiteaves to the belief that this species may be regarded as a characteristic one of the same general horizon.§ This view of the taxonomic value of the *Aucella* involves the conclusion that certain rocks in which it is the only abundant fossil, and for which provisional local names have been used in different parts of British Columbia, should likewise be regarded as representing inland extensions of the Queen Charlotte Islands formation, a conclusion in complete harmony with the stratigraphical and lithological evidence. The rocks referred to include the Tatlayoco Lake beds (7000 feet), Jackass Mountain beds (5000) and Skagit River beds (4400 or more) to which may be added (though as yet on little evidence other than lithological) the Nechacco series and the Cretaceous rocks known to hold coal on the upper part of the Skeena River.‖ To the south, in the vicinity of the West Coast, this earlier Cretaceous formation is doubtless represented by certain members at least of the Shasta group of California and Oregon.

In connection with the Yukon Expedition, in 1887 and 1888, important new observations bearing on the extent of the earlier

* Annual Report, Geol. Surv. Can., 1886, p. 17 D.

† Forming, part 2, Contributions to Can. Paleontology.

‡ Mesozoic Fossils, vol. i, p. 258.

§ A conclusion explained at length in the forthcoming publication by Mr. Whiteaves already referred to.

‖ These rocks may be found described in the reports of the Geological Survey of Canada as follows: 1875–76, p. 253, 1876–77, p. 90, 1877–78, p. 105 B., 1879–80, p. 102 B.

Cretaceous rocks have been made. At Rink Rapid, on the Lewes River (lat. 62° 20′ long. 136° 10′) and at Lake Labarge, further up on the same river, the writer found fossiliferous Cretaceous rocks which Mr. Whiteaves regards as probably also the same in age as those of the Queen Charlotte Islands formation.* Mr. McConnell has, further, discovered fossils belonging to the same fauna on Rat River (Rocky Mountains, lat. 67° 10′), on Porcupine River (lat. 67° 28′ long. 137° 47′) and on the main Pelly or Yukon River (lat. 65° 15′, long. 141° 40′). The characteristic *Aucella* above referred to is, however, the only species represented in two of these localities.

The various widely scattered observations above enumerated, now enable us to state, that a great earlier Cretaceous formation, beneath the horizon of the Dakota, is more or less continuously developed over a vast tract of country, the eastern edge of which lies to the east of the present line of the Rocky Mountains from the 49th parallel to the Arctic Ocean, and which is represented to the west as far as the vicinity of the mouth of Fraser River, the Queen Charlotte Islands, and in the Yukon Valley beyond the 141st meridian, in the interior of Alaska. Its existence may also be traced on the Alaskan Coast to the peninsula of Aliaska, in longitude 160° 31′ or farther.† It is impossible at present to define precisely the eastern margin of this formation, as in the area of the Great Plains sections are very seldom cut down to the base of the Cretaceous. From what is known, however, it appears probable that this line lies not far to the east of that of the Rocky Mountains, leading to the inference that some causal connection of an orogenic kind may exist between the eastern limit of these very massive Cretaceous accumulations and the position of this eastern member of the Cordillera. There is, however, in the southern interior of British Columbia, an extensive tract which includes the Selkirks and associated ranges, in which no Cretaceous rocks have been met with, and which it would appear, on this and other grounds, has been a land area throughout the Cretaceous period and a mountain system antedating those of the Rocky Mountains proper, the Coast Ranges of British Columbia and the Cascades of Oregon and Washington, in the flexures of which ranges Cretaceous rocks are involved. It is further probable that other yet undefined insular areas existed in the Cordillera region to the north and west, but the evidence now available shows, that to the north of the 54th parallel, in both the Triassic (" Alpine Trias ") and Cretaceous periods, the Pacific spread eastward in a more or less

* Annual Report, Geol. Surv. Can., 1887, pp. 146 B., 159 B.

† By collections made by Mr. W. H. Dall and others as detailed by Dr. C. A. White in Bulletin U. S. Geol. Survey, No. 4, 1884.

connected manner completely across the present position of the Cordillera belt.*

In the Queen Charlotte Islands, massive conglomerates immediately overlie that part of the section which has been referred to as the Queen Charlotte Islands formation. These, it has been suggested by Mr. Whiteaves, represent the horizon of the Dakota, and this reference is there strengthened by the fact that the conglomerates (2000 feet in thickness) are in turn overlain by shales holding *Inoceramus problematicus*. This occurrence of conglomerates appears, however, to have more than a local significance, for similar conglomerates are now known to occur in the same (overlying) position relatively to the earlier Cretaceous fauna in the northern part of Vancouver's Island, on the Lewes River, in the upper part or at the summit of the Tatlayoco, Jackass Mountain and Skagit series previously referred to, and are again found to overlie the Kootanie formation in the Rocky Mountains, forming there a portion of the thickness of beds between the Kootanie and Benton and consequently in all probability referable to the Dakota.

The constant or very frequent appearance of such massive conglomerates at or about the Dakota horizon, may fairly be taken to represent the initiation of an important and general subsidence, which seems to correspond as closely as possible with that referred to by Mr. Hill as the second great Cretaceous depression. It must be added, however, that in the northwestern portion of the continent, this second subsidence was not so profound as that described in the Arkansas–Texas region, and was interrupted, in the area of the plains, by at least one well-marked brackish-water and land epoch, represented by the Belly River and Dunvegan series of rocks.

The earlier Cretaceous rocks, here more particularly referred to, and named in widely separated portions of their extent the Kootanie and Queen Charlotte Islands formations, are again clearly analogous to Mr. Hill's Comanche formation, with which they have the same upward limit, and like it extend downward far beneath the base of the Cretaceous of the Interior Continental Plateau. In comparing the earlier Cretaceous rocks of these two portions of the continent, however, we find that though a distinct unconformity exists between the summit of the Comanche and base of the Dakota of the southwestern region of the United States, no such physical break is yet known as between the Kootanie or Queen Charlotte Islands formations and the Dakota; while the very great thickness of these formations, so far as it goes, may be regarded as tending

* Cf. on Triassic, Trans. Royal Soc. Can., vol. i, sec. 4, p. 144. Annual Report Geol. Surv. Can., 1885, p. 161 B.

rather to favor a belief in continuous sedimentation. Further, that while the base of the Comanche is described as equivalent to the Purbeck and Wealden, or lowest beds of the European Cretaceous, Mr. Whiteaves finds no evidence in the mollusks of even the lowest beds of the Kootanie and Queen Charlotte Islands formations of a horizon below that represented by the Gault in Europe. This can scarcely be regarded as divergent from the previous definition of the age of the same formations by their contained fossil plants, as the lower Cretaceous flora may be expected, from European and Asiatic analogies, to extend upward to the top of the Neocomian, between which and the Cenomanian the Gault may be said to be a transitional formation. The question, however, of the precise systematic position of these representatives of the earlier Cretaceous of the northwestern province of the continent, is one apart from that of their interrelation and general correspondence, which alone it is at present intended to point out. Finally, it may be noted, that while these formations mark the occurrence of a first Cretaceous subsidence in the northwestern portion of the continent, this subsidence has there been neither so great nor so continuous as in the case of the Comanche, a fact shown by the generally coarse, clastic character of the rocks, the comparative absence of limestones and the occurrence of beds of coal.

In this note it has been possible merely to outline the more interesting general results so far arrived at with respect to that part of the Cretaceous which underlies the Dakota horizon in British Columbia and in the western portion of the Northwest Territory. For details, some of which have important bearings on the general question, reference must be made to the various publications which have been cited and to forthcoming reports of the Geological Survey of Canada in which the facts more recently obtained will appear at length. The subjoined table presents in a diagramatic form the relations of the various formations above referred to, together with that of some overlying portions of the Cretaceous, not here specially alluded to, but which occur in the same region.

Geological Survey of Canada, April 20, 1889.

EXPLANATION OF MAP, p. 121.

The principal known localities of occurrence of the Earlier Cretaceous rocks, are indicated by the black dots. Nearly all of these represent places from which characteristic fossils have been obtained.

The eastern extension of the Pacific Ocean in the earlier part of the Cretaceous period is approximately shown by that of the unshaded part of the map.

TABLE ILLUSTRATING THE RELATIONS OF THE EARLIER CRETACEOUS FORMATIONS OF BRITISH COLUMBIA AND OF ADJACENT PARTS OF THE NORTHWEST TERRITORY.

Queen Charlotte Islands.	Comox, Vancouver Island.	Mainland of British Columbia.	Yukon District. (North of 60th parallel.)	Rocky Mountains Proper. (Between 49° and 51° 30′.)	Southern Alberta.
	Upper conglomerates, 320′ Upper shales, 776′ Mid. conglomerates, 1,100′ Middle shales, 76′ Lower conglomerates, 900′ Lower shales, 1,000′ Productive coal meas., 739′		Laramie of Lewes R.	Laramie (base).	Laramie, 5,750′
A. Upper shales and sandstones, 1,500′	(*Local base of Cretaceous.*)		(Intermediate formations probably represented, but not recognized.)	Pierre (including Fox Hill). Belly River. Benton (possibly with part of Niobrara, 1,400′).	Pierre (incl. Fox Hill), 830′ Belly River, 910′ Lower dark shales, 800′
B. Coarse conglomerates, 2,000′		Tatlayoco beds (7,000′), Nechacco beds (6,000′), Skeena beds, Skagit beds (4,400′ or more), Jackass Mt. beds (5,000′). All sandstones and quartzites, with shales, and generally coarse conglomerates ab'ye. "Porphyrite" series of Iltasyouco 10,000′ (probably passing up into above) of Tatlayoco, and possibly of Nechacco and Skeena.	Conglomerates of Rink Rapid, etc.	Dakota, apparently represented in part by coarse conglomerates, and including on Crow Nest Pass, 2,200′, of volcanic ejectamenta.	Dakota (probably).
C. Lower shales and sandstones (with coal), 5,000′			Fossiliferous shales and sandstones, on Rink Rapid, L. Labarge, etc.	Kootanie formation, 7,000′ or more. Sandstones, shales, etc., with coal.	(*Local base of Cretaceous.*)
D. Agglomerates, 3,500′					
E. Lower sandstones, 1,000′					
(*Local base of Cretaceous.*)		(*Local base of Cretaceous.*)	(*Local base of Cretaceous.*)	(*Local base of Cretaceous.*)	

ART. XV.—*A New Occurrence of Gyrolite;* by F. W. CLARKE.

IN the autumn of 1888, during a visit to the New Almaden Quicksilver Mine in California, Dr. D. T. Day of the United States Geological Survey was shown specimens of a mineral which was locally supposed to be white fluor spar. It occurred in well developed crystals lining crevice veins in the mine, and was easily recognizable as apophyllite. Dr. Day secured a good series of the specimens, and finally turned them over to me for examination. The largest crystals were about two centimeters in diameter, and fairly transparent, and grew out of crystalline masses of considerable thickness; the exposed definite faces nearly meeting at the center of the seam or vein. All of the specimens were saturated with bituminous matter, but except for that staining they were quite colorless.

In several of the specimens received the wall of the seam was distinctly shown, and between it and the crystalline apophyllite there was a fibrous layer from one to three centimeters in thickness. That layer was also colorless, except for bituminous staining, and on account of its relations to the apophyllite it appeared to deserve investigation. A sufficient quantity of the material having been selected, it was digested for about twenty-four hours with ether in order to cleanse it from bitumen, and then analyzed. I give the result in comparison with How's figures for a Nova Scotia gyrolite.

	Clarke.	How.
H_2O	14·60	15·05
SiO_2	52·54	51·90
Al_2O_3 }	0·71	1·27
Fe_2O_3 }		----
CaO	29·97	29·95
MgO	----	0·08
K_2O	1·56	1·60
Na_2O	0·27	----
F	0·65	----
	100·30	99·85
Less O	0·27	
	100·03	

It will at once be seen that the two analyses, except for the small amount of fluorine, coincide quite sharply, and establish the New Almaden mineral as gyrolite. The Nova Scotian gyrolite is also associated with apophyllite, from which species How supposed it to be derived.* In the present instance, however, the relative position of the two minerals in the vein suggests that the gyrolite is the older; and that the

* See this Journal, II, xxxii, 13.

apophyllite may have been formed from it by a partial solution and redeposition of its material through the agency of waters containing alkaline fluorides. The gyrolite is obviously not absolutely pure, but it agrees approximately with the formula $Ca_2Si_3O_8 . 3H_2O$. Its chemical structure and relations to apophyllite are not altogether clear.

Washington, May 24, 1889.

ART. XVI.—*On Action of Light on Allotropic Silver;* by M. CAREY LEA.

SINCE my last communication to this Journal I have obtained the following results:

1. It was mentioned in that paper that the red gold-colored modification of silver was converted into a bright yellow-colored form by the action of light. Continued exposure seems to produce little further change so long as the substance is dry. But if the paper on which the silver is extended, is kept moist by a wet pad, with three or four days of good sunshine the change goes on until the silver becomes perfectly white, is apparently changed to normal silver:*—water, alone, tends to darken this form of allotropic silver, accordingly the portion of the paper that was protected for comparison, darkened, showing that the whitening effect was due wholly to light.

It thus appears that light can convert yellow or red-yellow allotropic silver to white.

2. Some pieces of very bright blue-green modification were exposed to light and with about one day's bright sunshine, they passed to a pure bright metallic gold-color.

It appears therefore that light can cause the blue-green modification to pass to the gold-yellow.

This change only occurs with a very brilliant form of the bluish-green substance which is obtained with a quick short washing. Specimens slowly and very thoroughly washed which when brushed over paper gave a more mat color, did not yield this result but became brownish, as described in the July number of this Journal. Nor can this result be obtained with the soluble form of allotropic silver described in the June number of this Journal.

Light therefore can change the bluish green to the yellow modification, and this last (with the aid of moisture) to white normal silver. The silver thus obtained is pure white, lustrous and metallic, resembling silver leaf. Organic compounds of silver reduced by light give gray or black silver devoid of luster.

* The pad used was of unbleached muslin which was boiled several times with distilled water to remove everything soluble before use.

Art. XVII.—*On Certain Porphyrite Bosses in Northwestern New Jersey;* by J. F. Kemp.

Across the northwestern portion of New Jersey the Hudson River shales extend in a broad band some six miles or more in width.* The general trend of the outcrop is northeast. To the northwest they run under the Oneida conglomerate forming Kittatinny range, and on the southeast are themselves underlaid by limestone of earlier age. West of Deckertown the shales have been the scene of extensive eruptive phenomena. Between them and the Oneida conglomerate the great elæolite-syenite dike† described by Professor B. K. Emerson‡ comes out, causing extensive contact metamorphism, and a mile or less east of this dike and wholly in the slates are to be seen the curious bosses or hillocks of eruptive rock referred to in the New Jersey Report for 1882, p. 67. Also, some ten miles southeast, at Franklin Furnace, we find the bed of franklinite intersected by the several dikes of mica-diabase described by Professor Emerson,§ and other evidences of eruptive rocks were found by Dr. N. L. Britton northwest of Franklin Furnace.‖ From these citations it will be seen that records of eruptive action are numerous in this district over an area ten miles or more in diameter.

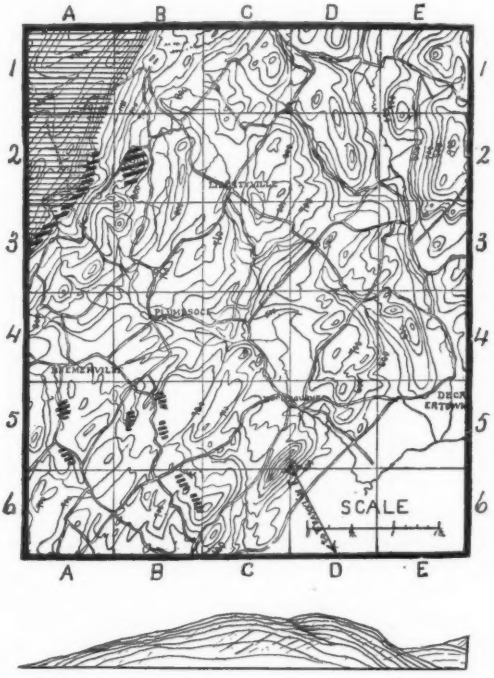
Having been engaged in studying a collection of massive rocks for the N. J. Survey in 1886, the writer felt interested, now that the survey has lapsed, in pursuing the subject further, and was so fortunate, while doing the field work, as to have the aid of Mr. William S. Vanderhuff of Deckertown, whose thorough knowledge of the district it would require long residence to equal.

The accompanying map illustrates the region and has been imperfectly reproduced from Sheet No. 1, of the State Survey maps and afterward partly filled in with right line work to show the portion formed by the Oneida Conglomerate. The shales strike generally northeast where a strike can be observed, but as the eruptive rocks are neared it is difficult to satisfy oneself as to their bedding, for it has been largely destroyed by the baking influences to which the shales have been subjected.

There are in all some eight exposures. These are distributed in an irregular north and south direction as indicated by heavy lining on the map. The largest is in B2, the other seven in A5, B5 and B6. The great dike of Professor Emerson runs

* Cf. Geol. of N. J., Map, 1881.
‡ This Journal, III, xxiii, p. 302.
‖ Geol. Surv. of N. J., p. 110, 1886.
† Geol. Surv. of N. J., p. 144, 1868.
§ Ibid., p. 376.

from A2 to A3. The exposure in B2 is a large hill which, in the words of the 1882 Report, p. 67, "rises very abruptly (33°) from the meadow to a height of 150 feet." This is the one on the farm of Mr. Rutan. Its outline viewed from the east is reproduced from a photograph in the figure below the map. The upper exposure in A5 is the one on the VanAuken farm and consists of "two low hills." The lower exposure in A5 is a low hill on the Howell farm. The westerly exposure in B5



is on the Stiver farm and consists of "two other but abrupt hillocks." The other four are not especially referred to in the report, but consist likewise of low hillocks or mounds. There are other spots which have clearly been subjected to the action of heat, but where no eruptive outcrop comes to the surface. The natural outcrops are not good and it is difficult to obtain specimens in which alteration is not far advanced, except where former prospect holes have been vainly sunk in the search for the precious metals. The pyrites disseminations in the contact shales have encouraged some such excavations.

What appears to be the original rock is generally a very finely crystalline ground-mass in which are developed numerous porphyritic crystals of biotite. Its composition is shown by analysis I in the following table. The crystals are often very thickly distributed through the mass and again are comparatively few. They run from microscopic dimensions up to two inches in diameter. The biotite is deep brown, almost black in color and well-nigh uniaxial, affording in convergent light an image, hardly, if at all, to be distinguished from a single cross and rings. As is to be expected it is optically negative. In the rock the mica is sometimes idiomorphic and sometimes in irregular masses. It frequently exhibits beautiful illustrations of crumpled and strained crystals and was evidently formed before solidification had set in. It alters concentrically from the edges.

Augite is especially abundant in the northern exposure, but less frequent in the others. It is greenish in tint, and exhibits well developed idiomorphic crystals bounded by the prism and pinacoids. In upper A5, it occurs altered in such a way as to resemble most closely serpentinized olivine crystals and on casual observation one would regard them as such. But by searching out the small unaltered fragments and testing the extinction angle they are seen to be augite. No hornblende whatever was found. Plagioclase seldom occurs in large crystals, but in the ground-mass is found by high powers to be present in quantity. In the available specimens it is generally in an advanced state of alteration and affords a light yellow, feebly refracting alteration product. Together with small masses of biotite, apatite needles and magnetite, it forms the ground-mass. The absence or very small amount of soda found in the analyses (see below), would indicate a plagioclase close to anorthite. Apatite is everywhere extremely abundant in well defined hexagonal crystals, often of unusual size. It constitutes one of the most remarkable features of the rock. Magnetite is abundant, without however showing indications of titanium. Pyrite is not infrequent. The ground-mass is an extremely finely crystalline base, composed of innumerable doubly refracting elements which are chiefly plagioclase, biotite and less abundantly augite. Two generative periods are thus clearly shown for the last two. In the majority of cases alteration is much advanced, yielding calcite in great quantity, so that the rocks often readily effervesce. In middle B5, titanite crystals are numerous but small.

An analysis of the biotite gave the results in column I; an analysis of the rock from B2, those in column II; another of the rock from upper A5, the results in column III.

	I.	II.	III.
SiO_2	34·61	40·47	31·8
Al_2O_3	15·74	11·86	18·78
Fe_2O_3	8·52	17·44	15·20
CaO	tr.	16·8	14·6
MgO	20·03	3·1	3·32
K_2O	17·14	4·21	5·074
Na_2O	tr.	1·90	1·10
P_2O_5			0·95
Loss on ignition	2·8	3·6	8·1
	98·84	99·38	98·924

The sulphur was not determined; a little is probably present from the pyrite. Spec. grav. of II, 3·102, of III, 2·939. No. III effervesced, No. II did not; alteration therefore lowers the spec. gravity.

Many surface fragments contain scattered through them in the greatest abundance pieces of shale which have become involved in the eruptive mass in its passage to the surface. Many fragments are little else than a kind of breccia of shale held together by a cement of porphyrite. They resemble nothing so closely as the fragments of rubbish that float about and adhere together on any standing liquid. The shale fragments have perfectly sharp edges and show no tendency to shade by contact fusion into the porphyrite.

Professor Emerson, in the paper on the elæolite-syenite dike referred to above, describes a large bowlder in the rear of Mr. Roloson's house near the syenite dike (this would be in the lower right-hand corner of A2), which is doubtless a stray piece of the B2 outcrop. The brief description given describes fairly well the latter, and some of the original sections which were studied by Professor Emerson have been kindly loaned the writer. They do not differ essentially from those of the rock in place, but the "square and hexagonal sections" which occur so abundantly in the rock in place have been determined by their high refractive power, by the absence of gelatinization such as would be indicated by successful staining which failed in repeated trials, and by the quite notable percentage of P_2O_5 in the second analysis above, to be apatite instead of nepheline. Its abundance, however, is, as stated above, one of the most remarkable features of the rock.

These masses have been described as bosses or knobs rather than dikes under which name the New Jersey report designates them because the large hill in B2 is nearly as broad as long and the other exposures resemble low knobs or blisters. It is possible that the mass of these hills under the soil may be baked shale with a backbone of eruptive rock in the form of a

dike, but the peculiar color of the soil, and the irregular outline suggesting at once eruptive rock, and the general distribution of surface fragments, have led to the adoption of the different view. It seems probable that they have been occasioned by the same eruptive action which caused the syenite dike to the west, notwithstanding their great basicity and totally different character. The syenite dike itself varies much in character throughout its extent and still merits further study on its north and south extremities. Connecting these phenomena with the dikes at the southeast and south it seems as if there has been a longitudinal manifestation of eruptive activity in an irregular north and south line and that it occurred after the close of the lower Silurian Period.

These rocks are to be classed with the porphyrites according to the types systematized by Rosenbusch* and would perhaps be made most clear in their relations under the name biotite-augite-porphyrite. They appear to be in many respects very similar to those summarized by Rosenbusch (op. cit., p. 471) and described by Beyschlag, Schmid and others from various parts of Thuringia. With these they seem to agree quite closely in mineral composition, structure and alteration products.

Geological Laboratory, Cornell University.

ART. XVIII.—*On the great lava flows and intrusive trap sheets of the Newark† system in New Jersey;* by NELSON H. DARTON, U. S. Geological Survey.

SEVERAL years ago the writer commenced a systematic study of the Newark system in the New Jersey region, and several seasons were spent in an endeavor to determine the structure, and the relations of the igneous rocks. The results of these studies will be published during the latter part of this year as a bulletin of the U. S. Geological Survey, and it is the purpose of this paper to give only some general statements in regard to the nature of the more prominent trap masses.

The larger masses of igneous rocks in the Newark system in New Jersey constitute thick sheets enclosed in gently inclined soft sediments and their outcropping edges rise abruptly from the surrounding plains as long, narrow ridges generally bared of overlying strata on their gentler inner slopes, and presenting escarpments or steep slopes toward the underlying beds.

* Mikros. Physiog. Mass. Gest., Band II, pp. 446 and ff.

† This name, originally used by Redfield for the red sandstone of New Jersey has recently been revived by Russell (Am. Geologist, vol. iii, p. 178) and applied to the Jura-Trias of the entire Atlantic slope.

The long, level-crested ridge extending with palisadal front along the Hudson River northward from New York for thirty miles is a well known member of the series, and the Watchung or Orange Mountains some miles westward are other conspicuous instances. Sourland Mountain crossing the Delaware just below Lambertsville, Cushetunk Mountain east of Clinton and the line of ridges extending from south of New Brunswick to the Delaware and beyond, embrace the other large masses.

The earlier writers, from Pierce in 1819 to Rogers in 1836, expressed opinions in regard to the origin and nature of the trap masses, but they were so vague and contradictory that their significance is hardly noteworthy.

Rogers was the first to definitely recognize the evidence of intrusion and he considered all the trap masses subsequent in date to the enclosing sediments.

In 1846 Emmons described the palisade trap near the New Jersey-New York line and presented evidence indicating its intrusive nature and sheet-like structure.

Cook, in the Geology of New Jersey, 1868, described all the larger trap masses as intruded sheets, and as evidence of the intrusive nature of the Watchung Mountain outcrops, refers to the occurrence of indurated shales and limestones on the back of the mountain, northwest of Plainfield (at Feltville) and to their analogy in general relations to the Palisade and other intrusive traps.

Russell, in 1878, described in some detail the occurrence of what were supposed to be intensely altered shales and limestone on the inner side of the first Watchung Mountain at Feltville, and added great weight to the prevailing view that the Watchung and all the other trap masses were intrusive.

In 1882, Davis visited several typical localities in the New Jersey area for the purpose of determining the nature of the traps, and while he agreed with previous observers, Emmons, Cook, Credner, and Russell, in regard to the intrusive nature of the palisade trap, he stated his conviction that the Watchung traps were extrusive and similar in relations to some of the extrusive sheets which he had studied in the Connecticut valley. He found the base of the second Watchung trap resting on apparent tuff deposits at Little Falls and the conformable base and the amygdular and ropy-surfaced rock of the first Watchung trap exposed near Paterson. At the Feltville locality he found no traces of the alteration described by Rogers, Cook, and Russell, but on the contrary, it was seen that the vesicular, slag-like rock was overlain by unaltered shales with an intervening trap breccia at some points. This breccia alone was considered satisfactory proof of the extrusive nature of the

sheet, and he stated his opinion that it could only have been formed on the surface of a pre-existent sheet of lava.

The writer's studies extending over the entire Newark area in New Jersey confirm Davis's suggestion and give rise to the following conclusions: The extrusive sheets, contemporaneous with the enclosing strata, include all the outcrops constituting the First and Second Watchung or Orange Mountain, and the ridges enclosed between them and the Archæan highlands, and the outlying outcrops near New Germantown. The intrusive sheets comprise those constituting the Palisades, Sourland Mountain, Cushetunk and Round Mountains, Lawrence Brook —Ten Mile Run Mountain—Rocky Hill—Pennington Mountain—Bald Pate and Jericho Hill series, and the outcrops at Point Pleasant, Snake Hills, Arlington, Martin's Dock, Neshanic, Belle Mountain, Granton and Brookville.

The extrusive sheets are characterized by their perfect conformity to the underlying strata, the deep vesicularity and alteration, or slag like aspect of their upper surfaces, the unaltered and undisturbed condition of the enclosing strata the presence of trap breccias at the contacts, the altered and frequently vesicular condition of the rock at their bases, the evidence of successive flows, their relations to anterior tuff deposits and their distinctive columnar structure and petrography.

The intrusive sheets are characterized by irregular lower contacts in which the trap cuts across the ragged edges of the strata for greater or less distances, the intense alteration in the enclosing strata, the increased density and fineness of grain and the bedded structure in the trap near the contacts, and the absence of vesicularity and breccias.

In the Watchung Mountains, erosion, glaciation and drift cover cause scarcity of outcrops of the original upper surfaces, but there are many localities scattered along their course in which deeply vesicular trap is exposed, and others in which unaltered and undisturbed strata outcrop very near the contact. The only actual overlap well exposed is in the ravine at Feltville, where the trap surface is in greater part vesicular and slag-like and the soft, red, argillaceous shales fill the irregularities, excepting at one point where there is an intervening trap breccia filling the interstices in a slag-like portion of the surface. Contacts of the Watchung traps with underlying strata are exposed at intervals along the outer sides of the ridges and absolute conformity prevails throughout. The trap is frequently vesicular and altered and lies on the unaltered or very slightly altered strata along a straight or gently sinuous line, in one case with a trap breccia intervening. At two points in its course the second Watchung trap is exposed overlying beds of loose

eruptive materials apparently scoria and tuff, and at other localities the sheet is seen to be composed of successive flows, the base of one lying on the vesicular surface of a preceding flow, in one case with an intervening layer of trap breccia at some points.

In thickness the first Watchung trap varies from 450 to 650 feet, the second, from 600 to 850 feet, and the third, from 225 to 350 feet in the main, and the area enclosed by the outermost hooks is about 500 square miles, no doubt in greater part underlain by trap, so that the Watchung sheets represent lava-flows of no mean volume. Apparently the extrusions were continuous throughout, for excepting the intercalated breccia above alluded to, no intervening or overlapping sedimentary materials were discovered. The absence of fragmental volcanic deposits, excepting the local beds at the base of the second Watchung sheet, is a noteworthy feature, and the first extrusions were not attended by ejections of scoria, ash, etc., or, at most, in sufficient amount to extend to the present lines of outcrop. The eruptions which gave rise to the Watchung trap masses were no doubt very similar to those of some of the great lava-flows of the western part of the United States, which appear to have welled forth from long fissures without attendant craters, or the ejection of fragmental materials.

The great hooks characterizing the southernmost outcrops of the Watchung traps are entirely due to flexure, and the bowed course of their northern terminations and of Towakhow Mountain are due to the same cause.

The New Vernon trap, across the Great Marsh from the Watchung Mountains, is apparently an extension of one of the Watchung flows brought up by the partial quaquaversal which determines its crescentic course, and it is similar to them in every respect but not so well exposed for study, while the New Germantown traps farther southwestward, but at approximately the same horizon, are undoubtedly extrusive and may be remnants of another extension of the Watchung flows.

The Palisade trap is the best exposed instance of intrusion on a large scale in New Jersey and although it is in greater part an essentially conformable sheet throughout, the supply dike from which the sheet extends reaches the surface northwest of Hoboken and in Rockland County, New York, along the inner side of the ridge and is in part finely exposed in the two tunnels of the West Shore railroad.

For many miles along the Hudson River the Palisade sheet is exposed in contact with the underlying strata near the base of the formation, and while the relations are essentially conformable throughout, local irregularities are frequent in which the ragged edges of the strata are crossed laterally up or down

for in one instance over 150 feet, and trap offshoots are sent down or out into the underlying beds. In the vicinity of Haverstraw the crescentic course of the dike causes a corresponding deflection in the line of outcrop, and although this is greatly aided by the structure of the outlying beds, the base of the sheet crosses the strata for several hundred feet in preserving its position above the surface. At its terminal outcrop, an occurrence of vesicular rock, suggests that the sheet was finally extruded. At its contacts with enclosing strata the Palisade trap becomes fine-grained, very dense and bedded in structure, and the sedimentary rocks are darkened and hardened often to a considerable distance.

A short distance west of the Palisade trap near the latitude of the city of New York, are the posterior trap masses of Granton and Snake Hills, similar structurally to the Palisade trap in consisting of a dike and a sheet extending up the dip.

While it seems probable that the Palisade trap continues southward to reappear in the series of outcrops which extend from Lawrence Brook through Rocky Hill and Pennington Mountain to Bald Pate and Jericho Hill on the Delaware, it is possible that it is due to an entirely separate intrusion. The trap of the series of outcrop from Lawrence Brook to Jericho Hill is similar to the Palisade sheet structurally and petrographically, and is apparently a continuous mass not reaching the surface in the gaps that isolate Pennington Mountain. It is heavily flanked with indurated shales and crosses the strike of the enclosing strata, both at intervals in its westerly course and in the hooked outcrop of Ten Mile Run Mountain.

Sourland Mountain consists of a thick sheet of coarse-grained diabase, heavily flanked by highly indurated shales, and follows the strike of the enclosing strata excepting in a local bowing near the center of its course where it crosses and recrosses the strata for a short distance. Cushetunk and Round Mountains are the remnants of a wide, thick, intrusive sheet considerably flexed, and eroded through at the anticlinals so as to give the singular horse-shoe shaped course to Cushetunk Mountain and isolation to Round Mountain. The indurated strata associated with this trap are crossed by it at some points, and along the western border for a short distance the edge of the sheet overlaps the Lower Paleozoic limestones and presents some evidence of having been extrusive.

The smaller trap masses along the Delaware, at Belle Mountain, Brookville, and Point Pleasant, are all local intrusive sheets intercalated between highly altered strata, and near Neshanic, Martin's Dock, and Arlington are other intrusive sheets, finely exposed in cross-section. The other trap masses in the New Jersey region are some small sheets and dikes near

and northeast of Flemington, the dike so finely exposed near Blackwell's Mills, the dike (?) near Hackensack and the sheets south of New Brunswick.

The ages of the intrusive sheets of the formation are difficult to estimate. Davis has called attention to the raggedness of some of the contacts as evidence that the intrusion was effected before the development of joints by the uplift of the formation, and this certainly seems very probable.

As the stratigraphy of the Newark system of the New Jersey region is not worked out, the horizons of the trap masses are not known, and the sequence of their intrusion is indeterminable from any evidence now in hand. For the greater part of its course the Palisade trap lies just above the basal arkose, which is known to overlap the crystalline rocks in wells in Jersey City, and as the first Watchung trap lies on basal beds near Paterson, it might be suggested that the two sheets are not far distant in horizon, but in the absence of definite knowledge of the comparative age of the basal rocks at Paterson, and the structure and the configuration of the buried Triassic shores in the intervening region, the relative positions of the two sheets can only be conjectured.

At Lawrence Brook the supposed southward continuation of the Palisade trap is not far above the base of the formation, but in Ten Mile Run Mountain and Rocky Hill the strata are crossed, so that at the Delaware the sheet is apparently 10,000 feet above the Trenton gneisses, but probably there are intervening faults which might decrease this estimate very greatly.

Sourland Mountain trap is apparently high in the formation, but its exact or relative horizon cannot be determined until the stratigraphy and structure of the region has been worked out and the same is the case with the other traps of the Delaware region, and the Cushetunk and Arlington traps.

ART. XIX.—*Recent Explorations in the Wappinger Valley Limestones and other formations of Dutchess Co., N. Y.;* by W. B. DWIGHT. With Plate VI.

No. 7. *Fossiliferous Strata of the Paradoxides Zone at Stissing.*

THE occurrence of fossiliferous Cambrian strata of the Potsdam group near Poughkeepsie, N. Y., and ten miles north of that city at Salt Point, has been described in previous papers of this series:* also the discovery by Mr. C. D. Walcott and myself, in a joint trip, of fossiliferous strata of the Olenellus horizon on the southern extremity of Stissing Mountain, 21

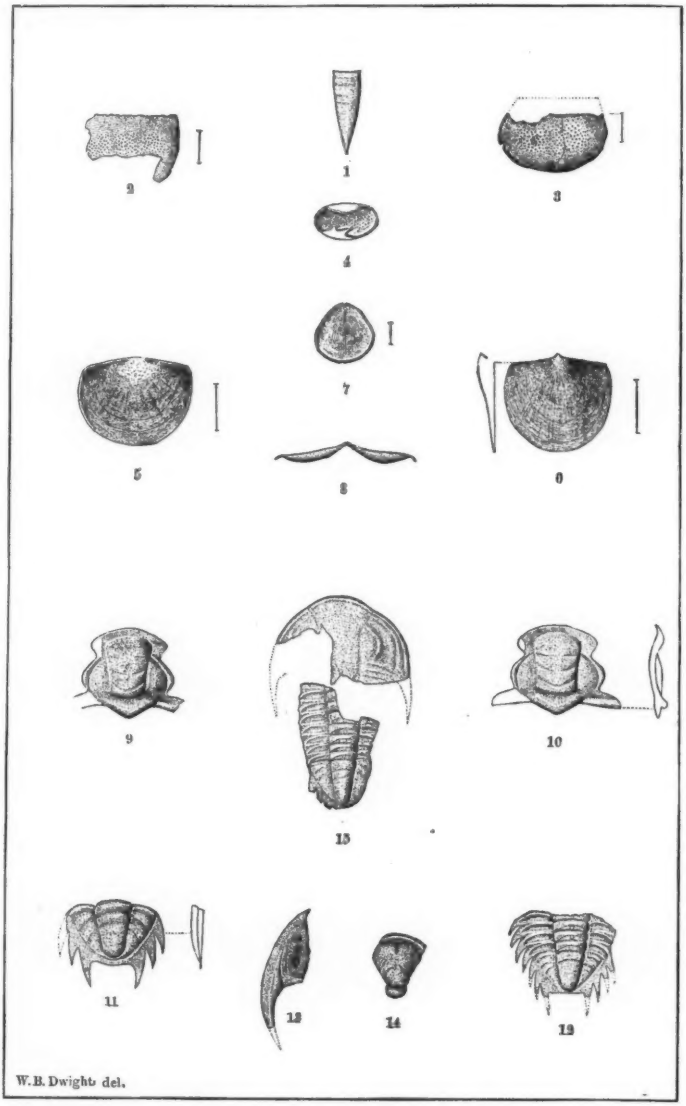
* This Journal, Feb., 1886, and July, 1887.

miles north of Poughkeepsie. It is the object of this paper to present a few of the prominent results of my more recent researches in the Cambrian and associated strata in that part of the county adjacent to Stissing Mountain.

The particular aim of these later investigations has been to ascertain the position and extent of the Olenellus strata, and their stratigraphic relations to the Hudson River shales of the region, and to the higher Cambrian strata whose presence a few miles to the southward had been already demonstrated.

The Olenellus quartzite and the overlying Olenellus limestone, rest upon the gneiss of Stissing Mountain around the entire circuit of its southern extremity and so continue northeastward for several miles along both its eastern and western flanks. At the southern extremity, about 21 miles northeasterly from Poughkeepsie, these strata cover the basal slopes of the mountain at an elevation of about 275 feet above the adjoining valleys and, conforming to these slopes, lie with a very gentle inclination to the south. On descending the slopes in southerly directions, the upper layers of the Olenellus limestone are found to run frequently into red shales which have not proved fossiliferous. In the fields which stretch southward and southwestward from the mountain, the rocks are to a great extent concealed by drift; but there are a sufficient number of outcrops to permit a continuous tracing of the limestones and calcareous shales (of whatever horizon they may be) for several miles, and to show that the dip rapidly increases, and the strike soon becomes the prevailing one of about N. 20° to 30° E. On account of the cover of drift, and the scarcity of fossils, it is at present impossible to determine exactly, along what lines the Olenellus group is succeeded by strata of later periods.

This mass of limestones of the Olenellus and to the southward probably of higher groups, which extends in the line of strike southwestward, is abruptly cut off on the west by a fault caused by the uplift of a belt of Olenellus quartzite, overlain on the west by a strip of limestone of the same age. West of this limestone are the shales of the Hudson River group. This fault begins at a point between two and three miles southwest of Mt. Stissing, where, however, only the limestone at first appears, faulting on the east (as well as the west) against Hudson River shale. This line of fault extends in a direction a little east of north to western flank of the mountain. One of the best places to observe it is one mile west from Stissing Station, on the road leading west beyond the corner of the McIntyre road, near Mr. Elias Turner's house. At this point the quartzite comes in, as a bold conspicuous ledge of white unfossiliferous rock. From this point northeastward, the quartzite faults against the Olenellus and associated limestones on the east, while



W. B. Dwight del.

it is bordered on the west by a belt, from 800 to 1000 feet wide in its outcrop of overlying limestone, partly at least of the Olenellus group.

After reaching the mountain, this belt follows along its flanks to Miller's Pond, during which course, the Hudson River shales on the west pinch out the limestone and rest against the quartzite for about 700 feet. North of Miller's Pond, the Olenellus belt begins to ascend the mountain flanks, until at a point about half a mile south of the "gap," the limestone entirely disappears, and the quartzite pressed upon by the Hudson River Shales stands out in bold white crags high up the mountain side,—at perhaps two-thirds of its height. North of this point, the Hudson River shales apparently rest directly upon the gneiss.

On the east side of Mount Stissing, the Olenellus belt does not tend at any point to climb its flanks; the tendency is rather to sheer away from them. The quartzite is here mainly on the west side of the belt. At a point, however, opposite to Attlebury Station, where there is a deep recess to the west in the outline of the mountain, there is a synclinal of limestone and calcareous shales lying west of the quartzite and filling up the gap.

At Mr. J. A. Thompson's house at the turn in the road northeast of Attlebury Station, the quartzite disappears in the meadows while the Olenellus limestone forms a bold escarpment along the base of the mountain, west of the road, for about half-a-mile farther north. Opercula of *Hyolithellus micans* occur in this limestone opposite Mr. Thompson's house. From this point the belt, much concealed by drift and alluvium, passes northeastwardly by and under the village of Pine Plains to the county line. There are outcrops of the quartzite in Mr. Henry Pitcher's swamp, north of the village, and on top of a hill belonging to Mrs. Henry Hoffman, and on the south side of the road close to the county line, near Mr. J. Weaver's house. There are outcrops of limestone in the plain near the north extremity of Stissing Mountain, which probably belong to this group, but this is uncertain. It may here be remarked that the Hudson River Shales mount to the summit of that part of the mountain lying north of the "gap," at least in its northern portion. Also that the only other place where I have found quartzite referable to the Olenellus group in this part of the county is a ledge in a ravine on Wing's farm a little southwest of the station at Willow Brook.*

* My explorations around Pine Plains were much facilitated by the generous assistance of Rev. A. Mattice, principal of Seymour Smith Institute.

Besides the strata already mentioned, there are limestones filling the eastern side of the valley east of the mountain, cropping out in Thomas's quarry on the northeastern edge of Pine Plains village, forming Mill Hill on its eastern edge, and other hills easterly as far as Bethel, and (in conjunction perhaps with the quartzite-limestone Olenellus belt,) passing north into Columbia County; also forming a belt about six miles long, and from a quarter of a mile to a mile wide in the Shekomeko valley, from Pulver's Corners on the north, to "The Square," two miles south of Shekomeko Station; also a very irregular strip about one mile and three quarters long and from a quarter of a mile to a mile in width, north of Bangall. All these outcrops I have searched and studied in detail, and have found them to be Cambro-Ordovician strata, much faulted against each other, and against the Hudson River Shales, especially in the Bangall strip. No Trenton outcrops have been found. Fossiliferous Calciferous strata occur at Attlebury Station, near the Moravian monument, at Bethel, and quite extensively at and south of Shekomeko.

The greater part of these limestones are Cambrian in appearance, passing very frequently into the calcareous shales characteristic of that zone in this county. But no fossils except those of the Calciferous strata have been found in any of the belts just named with the exception of a single fragment. This was found at the base of Mill Hill in Pine Plains Village, and may be either a Kutorgina or a Lingulepis. It is therefore at present impossible to determine the eastern edge of the Olenellus strata in the neighborhood of Pine Plains, or to distinguish, in this vicinity, the higher Cambrian strata, except in the single instance which will now be mentioned. It can scarcely be doubted, however, that the Potsdam zone is largely represented in connection with the Calciferous. The deep cutting on the railroad just north of Husted station is most probably in the Potsdam.

In July, 1887 the search in the limestones and calcareous shales immediately overlying the Olenellus limestone at the south end of Stissing Mountain was rewarded by the discovery of two or three fossils. No fossiliferous layer was then found; the organisms obtained were referred to the Potsdam zone which was to be expected in that position. It was not until the summer of 1888 that, by the discovery of a fossiliferous layer at this spot, the true significance of these important organisms began to appear.

The locality is in the first rock-cutting on the New York and Massachusetts Railroad, a little less than half a mile south of Stissing station. The organisms have been found chiefly in a thin layer of limestone and calcareous shales close to the

ground and to the railroad track, near the southern end of the cut, and are more abundant in the shale. Roadmaster Joseph D. Neal very kindly put at my disposal a gang of the railroad employees to make the necessary excavation. Mr. Palmateer, who has charge of this "section," rendered very efficient service in conducting the work, and showed much skill in detecting fossils.

The species collected consists of a trilobite, a Leperditia, and a Kutorgina, all undescribed, and a Hyolithes, probably "Billingsi." As the latter has a large geological range, it would scarcely indicate the horizon, but the other organisms appear definitely to indicate the Paradoxides horizon in their character and affinities. Well defined specimens are very rare, and have been procured only by breaking up a large quantity of rock; but in certain thin layers, fragments of these fossils are very numerous. On account of the covering of soil, it is impossible to determine the boundary line between these Paradoxides beds, and those known to be of the Olenellus group, three quarters of a mile north on Stissing Mountain. It is probable however that the outcrop in the gulley at the station is of the latter group. It is equally impossible at present to determine the division line between these Paradoxides beds and the Potsdam strata doubtless overlying them, which latter are entirely similar in lithological characteristics.

No other locality of fossils of the Paradoxides horizon has yet been found. The only fossils of Paradoxides types previously reported from New York State, are those found by Mr. C. D. Walcott of the U S. Geological Survey, which he states that he is inclined to refer to the Paradoxides zone.* I have not been able to find any of these in the Stissing locality.

It may be observed that the stratigraphic position of the Stissing Paradoxides fauna is in harmony with the view which now seems likely to meet with general acceptation, that if the Olenellus and Paradoxides faunæ are not synchronous, the former should be regarded as the earlier deposit. It gives me pleasure to acknowledge the very kind and valuable assistance of Mr. C. D. Walcott in determining the relations of my specimens to typical Cambrian fossils.

A description of the species determined is here appended.

Hyolithes Billingsi? Plate VI, fig. 1.

About half a dozen tubes of Hyolithes have been found in the calcareous shale: they are from eight to twelve millimeters in length, and from three to four in diameter at the aperture. Most of them are poorly preserved, showing little more than a

*This Journal, III, vol. xxxvii, 1889, pp. 385, 387.

black flattened cone. In one specimen, the shell shows considerable thickness. The one figured is the best one found, though it is the internal cast, the shell being entirely exfoliated. The shape is an acute cone very slightly convex on the visible surface, and with a few evident annulations in the upper half, the most marked one being next to the aperture. The shape of the transverse section is unknown, though it has been sought for by making cross-sections.

A single operculum has been found, but it is not sufficiently perfect to warrant its description. This fossil may be most safely referred to *H. Billingsi*. Specimens of the above named species, kindly loaned to me for examination by Mr. C. D. Walcott, show distinctly the annulations which appear in the Stissing fossils.

Leperditia ebenina, n. sp. Plate VI, figs. 2, 3 and 4.

Carapace jet-black, shining, subelliptical; about eight millimeters long, and five millimeters high in the largest specimens collected. Dorsal margin straight, or nearly so, somewhat shorter than the longest diameter of the carapace. Ventral margin arcuate; terminal margins well-rounded ventrally, but above sloping inward, in straight lines, to the dorsal margin; dorsal angles somewhat obtuse, not at all rounded.

The carapace in general is quite convex; in the largest specimens, as in one of those here figured (fig. 3), there is a broad and rather flat depression passing centrally from the dorsal to the ventral edge, leaving two terminal prominences; but as in such cases cracks are evident in the shell, and as the smaller specimens do not exhibit this feature, it is probably the result of compression. On account of the imperfection of the specimens, and the frequent distortion by pressure, it is not at present possible to determine the normal outlines of surface convexity.

The external surface of the carapace is very peculiarly ornamented. The entire border of each valve, in the form of a strip which is nearly two millimeters wide in the largest specimens, is covered with extremely minute contiguous pits. There are at least from 100 to 150 to a square millimeter. Within this finely-pitted border, the entire central portion is covered with much larger, separated pits, the interspaces being as wide as the pits themselves, or wider. Their disposition is very irregular, but they average about 15 or 20 to the square millimeter. There is a linear marginal groove extending along the ventral border; at its central point it is nearly one millimeter within the ventral margin, but it gradually approaches it toward each extremity until it coalesces with the terminal margins. The central portions of the internal surface of the

valves are covered with well-defined scattered tubercles, corresponding apparently with the scattered pits of the external surface.

No eye-tubercle nor muscle-spot is visible. Further particulars, as to relative obliquity of the dorsal angles, etc., cannot be ascertained until more perfect specimens are collected. In specimen No. 175, the valve appears to be a little wider on the left-hand than on the right-hand; it is therefore probable that the specimen is the right valve.

Found chiefly in the calcareous shale, but occasionally in the compact limestone. Some surfaces of the shale are black with its fragments, but owing to its brittleness no perfect specimens has been yet obtained.

Kutorgina Stissingensis, n. sp. Plate VI, figs. 5, 6, 7 and 8.

Shell black, phosphatic, slightly transverse; width about three-tenths greater than the length. Those collected from the limestone are about eight millimeters in width; specimens found in the calcareous shale are sometimes from eleven to twelve millimeters wide or even more. General shape, semicircular.

The cardinal margin slopes forward somewhat on each side of the beak, and makes obtuse angles with the lateral margins, on account of the incurving of the latter. It is shorter than the greatest width of the shell which is along a transverse line one-third of the distance from the beak to the front. Hinge-line not evident, but apparently a little curved.

The ventral valve has the beak elevated, pointed, and projecting somewhat behind the cardinal margin. From the beak the surface slopes down toward each lateral margin, and to the front margin, becoming sometimes slightly concave at the central portions of the shell. Along the cardinal border the shell is suddenly deflexed, making a distinct false area which, however, is separated into two parts by a vacant deltidial space under the beak. As the surface of this false area is exfoliated in specimens observed, it cannot be positively determined whether the surface ornamentation of the valve is extended over it. The edge between the false area and the upper surface of the valve is not sharp, but gently rounded.

The dorsal valve is depressed and nearly flat, beak low; otherwise resembles the ventral valve, except that in specimens collected it appears a little more transverse.

The surfaces of both valves are covered with very fine, sharp, concentric ridges, traversed by striæ scarcely visible to the naked eye. Under a strong triplet these striæ prove to be very delicate longitudinal undulations radiating from the beak.

The concentric ridges are somewhat wavy as seen under a strong magnifier; they are semi-circular; a number of those lying nearest to the front margin, run out along the upper part of the lateral margins; but the remainder, and larger number terminate in regular order along the cardinal border. In front of the central portions of the shell, the concentric ridges, which number about 12 to 15 to a millimeter, are regularly concentric; but nearer to the beak the number, and the irregularity greatly increase. At a point about one-third the length of the shell, from the beak, there are twenty-five or more to the millimeter; as the radiating plications are numerous in this part, there is caused a complexity of curves, which under a powerful magnifier produces the effect of elegant and delicate basket work. The radiating undulations are very irregular in position and number, they are not thoroughly continuous from the beak, in specimens observed, but appear at irregular intervals singly or in groups; while apt to be crowded around the beak, they are rare near the front margin. On the best specimens, about 25 have been counted in the central parts of the shell just forward of the beak; had they extended in equal distribution around it, quite to the cardinal border, there would have been about 50. They are also unequal in breadth; where they are somewhat regular, the interspaces about equal the plications in width; these plications are multiplied by implantation.

The following internal markings are indicated by the study of a specimen (fig. 8,) which is supposed to be an umbonal fragment of a ventral valve of a *Kutorgina Stissingensis*, from the same locality.

The original specimen is a natural impression of the interior. The figure is drawn from a gutta-percha cast of the same, which therefore represents accurately the interior of the valve. In front of the deltidial groove, a thin medial septum extends toward the front. Lying close to this septum and divided by it, there is a posterior and an anterior pair of circular muscular impressions, separated from each other by a broad and low transverse ridge. Fine radiating lines extend out from along the septum, the front ones making a small angle with the latter, while the more posterior ones start out from the septum in a lateral direction, but are soon deflected into their proper radial position.

It is not quite certain that this latter fossil is identical with *K. Stissingensis*. It is an example of rather numerous organisms found at this locality, which for some time I supposed to be a new species of Lingulella, allied to *L. ella*. But as its surface-ornamentation appears to be quite exactly that of the *K. Stissingensis*, and for other reasons, I am now inclined to think

that these little shells are either the young, or else fragmentary portions near the beak, of *L. Stissingensis.*

In the above description I have associated in the same species the specimens found in the calcareous shale, and those found in the compact limestone. There are some points of difference, especially in size; those in the shale are decidedly larger than those in the limestone, which may be due to more congenial sediment. The number found in the limestone however is too small to justify any strong conviction on this point.

Should it be ascertained hereafter that there are specific differences between these fossils, I should consider the specific name here given to belong to the specimens found in the limestone of which those corresponding to figs. 5 and 6 are the types.

Fragments of the front portion of this black shell are abundant and conspicuous in the shale, and in the absence of the associated fossils would readily be mistaken for fragments of *Lingulepis pinniformis.* Close inspection will however reveal this difference. The concentric ridges or laminae of *L. pinniformis* (at least as exhibited in Dutchess County, N. Y.) are feebly defined when magnified, and often run together obscurely; while those of *Kutorgina Stissingensis* as viewed with a strong triplet, are deeply cut, and in the front portions even, they are generally individualized with exquisite perfection.

This Kutorgina is related to *K. Labradorica* Billings; but the beaks are less elevated than the specimens figured of that species, and the peculiar surface ornamentation is different.

Olenoides Stissingensis, n. sp. Plate VI, figs. 9–15.

Body elongate ovate; in the single full-length specimen found, slightly over three centimeters in length.

Head large, semicircular, with apparently slight notches in the anterior outline, at the points of intersection with the facial suture. Eyes elongate and large.

Glabella elongate, its length in front of the occipital furrow, being nearly one and two thirds times its least width; a little expanded at the rounded anterior extremity, the sides slightly incurved along the posterior half, so that the shortest transverse diameter is a little in front of the posterior extremity. Dorsal furrow everywhere well defined, though not deep; inclined to be rather broad along the lateral edges. Glabellar furrows three, or, in some specimens, four; the first pair are broadly and deeply impressed in the edges of the glabella, at a point about one-fourth of the longitudinal diameter from the posterior extremity; from here they pass very obliquely backward, shallowing and narrowing rapidly, until quite near to the posterior margin, they are joined by a shallow transverse furrow. The

second pair arising from the central points in the edges are almost as oblique as the first pair and quite similar, except that they are slightly narrower, and considerably shorter, each one extending but a third of the distance across the glabella; the third and fourth furrows are very short and slight, often barely perceptible, and their direction is either directly transverse, or turned slightly forward.

Occipital furrow strongly defined at its outer extremities, where it terminates in pit-like depressions, but it is narrow, and very shallow toward the center.

Occipital ring, triangular, depressed convex, lower than the the glabella, very broad centrally, narrowing rapidly toward the lateral terminations; the postero-lateral margins pass directly to the fixed cheeks as elevated ridges, with only a slight transverse depression in the line of the occipital furrow. The occipital ring terminates posteriorly in an obtuse point. No occipital spine has been detected in specimens favorable for its exhibition if one were present.

The facial suture anteriorly passes obliquely forward and outward, in a sigmoid curve, from the anterior corner of the eye; from the posterior corner of the same, it runs nearly parallel to the posterior margin, until it turns and cuts this margin near the cheek-spine.

The fixed cheeks are broad, convex, elevated, but lower than the glabella; there is a deep furrow just within the well-marked palpebral-lobes; posterior limb with nearly parallel margins, and about as long as the shortest transverse diameter of the glabella; its furrow is broad and central at the inner end, but passes obliquely forward, as it vanishes before reaching the extremity. Front limb narrow, sloping upward from the dorsal furrow, elevated and rounding over at the margin; its contour is a curve of somewhat longer radius than that of the anterior outline of the glabella. Ocular ridge narrow and prominent, semicircular, extending anteriorly to the glabella at a point near the anterior end between the third and fourth furrows.

Free cheeks not well preserved in specimens collected; exclusive of the moderately long genal spine, their form is triangular, and the surface generally convex, rising towards the palpebral lobes. In the best preserved specimens there appears to be a narrow, flat, depressed margin, running down somewhat into the spine; from the anterior part of this margin, a deep furrow extends obliquely posteriorly, and inward, till it meets the posterior margin near the genal angle; it thus cuts off a strip of the convex portion of the cheek, which strip passes down into the spine to its point.

Hypostoma triangular, convex, well-rounded anteriorly, and the curved outline extending backward for more than $\frac{1}{3}$ of the

distance along the sides; from this point, the sides are nearly straight, except at the posterior end, where there is an expansion into a broad, rounded, well-marked annulation, whose outlines are everywhere curved. Between the ring and the main body is a transverse, linear, deeply impressed furrow. There is a pair of short faint furrows, together forming a V, just in front of the posterior transverse furrow on each side.

From the central point of the front edge, a broad moderately deep furrow, extends a short distance backward, rapidly contracting to a vanishing point; it obscurely divides the anterior part of the hypostoma into two lobes. There is anteriorly, a narrow, rounded margin whose contour conforms to that of the front edge of the principal mass. It is uncertain from the partially imbedded specimens, whether or not, this margin extends also along the sides.

The thorax contains eight segments. Axis well-elevated, strongly convex, rate of taper regular, about one part in six. Each segment is of about the same width as the corresponding pleural segment, exclusive of the free spinous portion.

A linear furrow, deeply impressed, passing from one posterior corner to the other, traverses each segment through its central point. This furrow thus presents the shape of an arc convex anteriorly. Immediately behind its central and highest point there is a tubercle, or perhaps the base of a spine. All that portion of each segment lying within, and posterior to the furrow, presents a visible contrast to the anterior portion by some slight difference in the texture of its surface, which, for one thing, is a little the rougher; in the two specimens collected, it is also of a darker color. The pleural segments are depressed convex, and extend out very nearly at right angles to the central line of the axis, until the free spinous portions are reached. Each of the pleuræ consists of a broad, flat depressed portion or furrow, flanked by narrow, well-defined marginal ridges. The furrow is broad at its inner end, and continues of equal width for half the distance, when it rapidly draws down to a point. The posterior pleural ridge is almost perfectly straight through its entire length; the anterior ridge is straight for about half its length, while it lies appressed against the posterior ridge of the next segment in front; from this point it is at first gently, then rapidly recurved until it meets in an acute point the posterior ridge of its own segment. All the narrowing of the pleuræ is thus effected from the anterior side. The pleural segments are prolonged into flat, acute, recurved spines, with broad contiguous bases; their length is about two-thirds that of the main segments; their inner, concave edges appear to be continuations of the posterior pleural ridges.

Pygidium of moderate size, triangular; axis strong elevated, obconical; with at least two well-impressed transverse furrows near the anterior end, forming there two conspicuous annular lobes, and apparently in some specimens, another faint furrow still farther to the rear. No tubercles detected. The lateral lobes consist of an inner depressed-convex portion, much lower than the axis, traversed by two or three oblique furrows corresponding with the spines, the posterior one, however, quite faint, and a perfectly flat and moderately broad margin from which three flat and acute spines extend backward. These much resemble the pleural spines, but have a less graceful appearance from the tendency of their edges to run into straight lines. The two posterior spines, one on each side, are about as far apart as the width of the axis of the pygidium at its anterior end; the border of the posterior margin which unites them, is nearly or quite a straight line.

Quite a number of specimens have been collected of the glabella and pygidium of this trilobite, in which the features as here described are quite constant. Only one has been found (fig. 5) which exhibits the contour of the complete cephalic shield, and two which show the thoracic segments.

On account of the imperfection of the head and pygidium of the more complete specimen, No. 180 (which I will consider, in any event, the type of the species "*Stissingensis*"), there might be doubt concerning its specific identity with the others. Specimen No. 182 is a link, however, which seems to remove all question from the evidence. The name assigned to the species is that of Mount Stissing, near whose base it occurs.

The close affinity of this trilobite to the type *Olenoides Nevadensis*,* Meek, is very evident and interesting. The main points of difference are: (1) The more slender and tapering thoracic axis. (2) The shape of the axial thoracic segments, and the arrangement of the furrow in these segments. (3) The broad, flat pleural thoracic spinous processes. (4) The different structure of the pygidium.

The glabella and fixed cheeks are also considerably unlike those of "*Ogygia serrata*" Rominger, which Mr. C. D. Walcott, after careful comparison of specimens, considers to be identical with *Olenoides Nevadensis*.† From the calcareous shale, and rarely in the compact limestone.

8. *Discovery of Calciferous Fossils in the Millerton–Fishkill limestone belt; also in a belt near Rhinebeck.*

The Hillsdale-Copake belt of the original Taconic limestone, dividing just south of Copake, enters the northeast corner of

* See Bulletin No. 30, U. S. Geological Survey, Plate xxv, fig. 7.

† This Journal, III, vol. xxxvi, 1888, p. 165.

Dutchess Co., in two main belts, the western or Pine Plains—New Hamburg belt, and the eastern, or Millerton-Fishkill belt. Associated with these are a few shorter parallel belts of limestone. The western one has been considerably altered by metamorphic action, but the metamorphic alteration has been much greater in the eastern belt where the limestones are frequently found coarsely crystallized and marble-like, while the associated shales often merge into micaceous or hydro-micaceous schists, or even become gneissoid. These facts were clearly set forth by Professor J. D. Dana, in 1879,* as also the fact that Lower Silurian fossils had been discovered in the western belt, while no definite species of fossils had been made out among the signs of organisms found in the eastern one.

Recently the writer visited the northern end of the Millerton–Fishkill belt, for the first time, in the work of exploration, entering it from the central part of the Shekomeko Valley. The limestone was reached at the eastern base of the high ridge of argillite and micaceous schist which is the southern extension of Winchell Mountains. At once the presence of fossils was discovered in a limestone ledge on the farm of Mr. Edward Clark. The locality is a little less than a quarter of a mile from the village of North East Center, on the Shekomeko road, and scarcely more than one and a half miles, in a straight line, from Millerton railway station. It is about five hundred feet northerly from the road, and but slightly elevated above the surface; the portion exposed is about one hundred and fifty feet long and sixty feet wide, with a strike N. 11° E. (true) and dip 35° westerly.

The rock is a fair sample of the much altered limestone of this eastern belt; its color varies from gray to white, and in many spots it is rather brittle, or inclined to crumble under blows of the hammer. In some cases, where the mass of the rock is grayish, the fossils in it are quite white, making a fine contrast. This fossiliferous limestone is frequently filled with films which very strongly resemble micaceous or hydro-micaceous films; but as I have not had time to examine them carefully I do not venture to assert that they are any other than films of gypsum.

The limestone in this ledge is filled with organic remains, some of which are fairly well defined, appearing in relief on the weathered surfaces;—many of them are distorted by pressure. The so-called Calciferous fucoids are abundant and of the same peculiar forms elsewhere observed in this formation. *Ophileta complanata* (which according to Prof. R. P. Whitfield is identical with *O. compacta*), is present in numerous

* This Journal, vol. xvii, May, 1879.

specimens, though not generally well preserved. I obtained four or five good specimens of it about $2\frac{3}{4}$ centimeters in diameter. Specimens resembling *O. sordida* were observed, but I suspect that they are simply distorted forms of *O. complanata*, as the gain in the size of the whorls is moderate.

An Orthoceras was found, conspicuous in its relief upon the weathered surface. It is about five centimeters long, and one and a third wide; the rate of taper is moderate; the septa number about seven to a centimeter: they are quite oblique, but this may be due to distortion. The siphuncle is two millimeters in diameter; the shape of the cross-section, and position of the siphuncle cannot be known because of the distortion, nor can its species be at present determined. Fragments likely to be those of *Cyrtoceras Vassarina* were also noticed.

No other limestone outcrops were seen in the vicinity, as the rock is extensively covered by drift in this part of the State, though a more careful search would doubtless reveal other localities. Similar fossils were found in adjoining walls indicating a considerable area of the fossiliferous strata. The limestone belt here has a width of about two miles, its eastern edge skirting the base of Indian Mountain in the Connecticut border. Throughout this width there appears to be a general similarity in the lithological characters so far as these could be observed in the rather scarce outcrops. The strata from the village of North East Center are continuous northerly to Millerton and to the north county line, becoming a white and crystalline friable marble in the quarry of the A. H. Maltby furnace, north of Millerton. The belt was also cursorily examined south as far as Amenia, and found to be of a similar character.

These facts show that the Calciferous, which is clearly indicated by the fossils, is at least one of the most prominent components of the Millerton–Fishkill limestone belt. Trenton strata are very likely to be present, but were not observed. No indications of Cambrian strata were noticed between Millerton and Amenia but the search has not yet been thorough. The shales and schists associated with these limestones, and passing sometimes from argillite, without interruption, into hydro-micaceous schist, hold evidently the same stratigraphic position as the shales and schists which are associated with the similar western limestone belts of the county. It is therefore not easy to see how they can be referred to any other horizon than that of the Hudson River Group.

It may be well to announce here that the writer has also found, recently, Calciferous fossils in one of the short belts of limestone lying a few miles east of Rhinebeck village. The fossiliferous locality is at Eighmyville three miles northeast of

Rhinebeck. This limestone has been mentioned by Mr. S. W. Ford, as probably Cambrian, and it contains in considerable quantity what certainly appears like the Potsdam conglomerate of Dutchess and Columbia counties. But the presence of the Calciferous there in a very characteristic form is now beyond doubt.

NOTE.—Since the above paper was written, Mr. C. D. Walcott's article on the "Position of the Olenellus Fauna," in the July number of this Journal, has been published. In this paper he very justly calls attention to the fact that the fauna here described belongs to the type of the Middle Cambrian of the interior (as of the Rocky Mountain region) rather than to that of the typical Paradoxides of the Atlantic coast; and that, from its position, the Hudson Valley fauna serves in a measure to connect the two.

EXPLANATION OF PLATE VI.

CAMBRIAN FOSSILS FROM STISSING, N. Y.

Natural size, except where otherwise noted. All are from the Calcareous shales, except those represented by figs. 5, 6, and 15, which are from the limestones.

Fig. 1. *Hyolithes Billingsi* (?) cast of interior, showing three or four slight annulations; the anterior one more prominent than the others.

Fig. 2. *Leperditia ebenina*, n. sp., enlarged to 2 diameters; fragment of (right?) valve, showing the line of the hinge, and a sloping dorsal angle, also the outer belt of minute contiguous pits, and the inner tract of larger separated pits. The ornamentation indicates that the complete carapace must have been at least one-sixth longer than the fragment.

Fig 3. *L. ebenina* enlarged to 2 diameters: lacking the cardinal margin; showing perfectly the peculiar surface-pitting, and the ventral furrow.

Fig. 4. *L. ebenina*, interior view of a central fragment of a valve; showing the separated tubercles, corresponding to the separated pits of the central exterior.

Enlarged to 2 diameters.

Fig. 5. *Kutorgina Stissingensis*, n. sp., enlarged 2 diameters; a natural cast of the dorsal valve.

Fig. 6. *K. Stissingensis;* enlarged to 2 diameters; ventral valve; with a side view of the elevation.

Fig. 7. Gutta percha cast of a natural impression of the interior of the umbonal region of a ventral valve, referred to *K. Stissingensis;* showing a medial septum from which fine striæ diverge, and muscular impressions, enlarged to 3 diameters.

Fig 8. *K. Stissingensis*, cardinal view; showing false area, deltidial opening, and the rounded edge between the false area and the main surface of the valve; enlarged to 2 diameters.

Figs. 9. and 10. *Olenoides Stissingensis*, n. sp.; the glabella. Fig. 9 from an artificial cast, Fig 10 with a side view of the elevation.

Fig. 11. *O. Stissingensis*, pygidium.

Fig. 12. *O. Stissingensis*, pygidium, with four attached thoracic segments.

Fig. 13. A free cheek, associated with *O. Stissingensis.*

Fig. 14. Hypostoma of *O. Stissingensis.*

Fig. 15. *O. Stissingensis*, full length, showing eight thoracic segments; details of the glabella obliterated or distorted by compression.

Art. XX.—*Silicic Acids;* by George F. Becker.

The silicic acids usually assumed to be needful to account for the natural silicates are ortho-, meta-, poly-, and disilicic and these are represented by the formulas H^4SiO^4, H^2SiO^3, $H^4Si^3O^8$ and $H^2Si^2O^5$. Professor P. Groth, however, points out* that polysilicic acid may be regarded as compounded of disilicic and metasilicic acids, since $H^2Si^2O^5+H^2SiO^3=H^4Si^3O^8$. This method of viewing these compounds has the advantage of reducing the acids to three in number. On the other hand polysilicates (orthoclase and albite) are among the most abundant substances in the accessible portion of the earth, while disilicates are extremely rare, and are commonly considered as being represented only by petalite and milarite. The latter is known in but one locality, and petalite is very sparsely distributed. If disilicic acid is really a constituent of the alkaline feldspars, it seems strange that it should not more often appear independently. The other hypothetical component of polysilicic acid is little less common than polysilicic acid itself.

The series of acids may be simplified in another way to which I have seen no reference. Orthosilicic and polysilicic acids may be conceived as united to form metasilicic acid, for

$$H^4SiO^4+H^4Si^3O^8=4H^2SiO^3.$$

On this hypothesis also the acids are reduced to three, and, furthermore, the acids supposed to unite are each very abundant in nature. This is a distinct advantage. There seem also some grounds in the behavior of the silicates favorable to this view of their constitution. It is known that the metasilicates of a metal are more stable than the orthosilicates. Now if a molecule of an orthosilicate combines with a molecule of a polysilicate, the union of the two must be attended with the liberation of heat and the compound must be more stable than its proximate constituents. In so far the behavior of the metasilicates accords with the hypothesis.

Again, the most important metasilicates are the amphiboles and pyroxenes, and, as Groth remarks, these two series afford most remarkable examples of the crystallization of the same substances in forms belonging to three different crystallographic systems, yet presenting extraordinary similarity in their angles. Such relations seem more readily reconcilable with the hypothesis that these ferro-magnesian minerals are double compounds of two acids than with the theory that they are substitution products of a single acid. One can easily im-

* Tabell. Uebersicht der Min., 1882, p. 75.

agine diopside (for example) as a calcium salt of A combined with a magnesium salt of B, and tremolite as a magnesium salt of A in combination with a calcium salt of B. Uralitization would then be represented as an interchange of bases between the two acids. The modulation from one crystallographic system to another is no doubt due to substitution, however these metasilicates may be regarded, but the dimorphism which extends throughout the two series yielding pyroxenes and amphiboles of similar composition, shows that the basic molecules are united with the acid groups in two distinct ways and, in the non-aluminous members of the series, it is difficult to see how this can be unless the acid is complex.

Were the metasilicates and particularly the pyroxene-amphibole group to be considered as ortho-polysilicates they would present a close parallelism to the composite feldspars. Nearly all mineralogists now accept the theory of isomorphous mixtures of anorthite and albite. The former is of course an orthosilicate and the latter a polysilicate. These isomorphous mixtures would seem to represent in reality some slight chemico-physical reaction between the components for, if no energy were depotentialized in the formation of the mixtures, these would have no tendency to form, and if energy is dissipated by the union of albite and anorthite, some action (perhaps comparable to solution) must occur. That these isomorphous mixtures should be accompanied in nature by double salts of the same acids, but in part containing different bases, seems very natural. The hypothesis that the metasilicates are double salts evidently does not preclude the theory that they too are sometimes isomorphous mixtures.

The studies of Messrs. Brush and E. S. Dana on the spodumene of Branchville* show that when this pyroxene undergoes decomposition, a part of the lithium is replaced by sodium, and that the mineral breaks up into eucryptite and albite. This decomposition can be neatly exhibited in accordance with the hypothesis here suggested by means of structural formulas similar to those which Prof. F. W. Clarke has so effectively employed. Spodumene† and its decomposition-products may then be represented by

$\diagup Si^2O^6 \equiv Li^2$	$\diagup Si^2O^6 \equiv Na^2$	$\diagup SiO^4 \equiv Li^2$
$Al-Si^2O^6 \equiv Al$	$Al-Si^2O^6 \equiv Al$	$Al-SiO^4 \equiv Al$
$\diagdown Si^2O^6 \equiv Al$	$\diagdown Si^2O^6 \equiv Al$	$\diagdown SiO^4 \equiv Al$
Spodumene.	Albite.	Eucryptite.

so that two molecules of spodumene, as here written, are resolved into one molecule each of the other minerals when one

* System of Mineralogy, App. III. † Amer. Chem. Journ., vol. x, No. 2.

half of the lithium is replaced by sodium. In this case metasilicic acid actually breaks up into polysilicic and orthosilicic acid. Were the process of decomposition to be reversed, or were albite and eucryptite, together with some appropriate lithium compound, to be mingled under the physical conditions which prevailed when the spodumene formed, this pyroxene would be regenerated. This case consequently appears to demonstrate that a metasilicate, one indeed of a peculiarly important group of metasilicates, may be produced by the union of orthosilicic and polysilicic components.

It remains to be considered how disilicic acid is to be regarded. If the synthesis of molecules is practicable, the resolution of molecules is also feasible. Why then may disilicic acid not be considered as a polysilicic acid from which orthosilicic acid has been isolated? This process would be represented by

$$3H^4Si^2O^4 - H^4SiO^4 = 4H^2Si^2O^5.$$

Were such really the process by which disilicic acid is produced, one would expect to find some hints of it in the occurrence of the disilicates. As a matter of fact, petalite occurs at the original locality in Sweden with lepidolite, which is an orthosilicate similar in composition to petalite. Tschermak regards lepidolite as a mixture principally composed of the silicate (Li, K) $AlSiO^4$. If the formula of petalite is (Li, Na) $Al(Si^2O^5)^2$, as it is usually written, then two molecules of petalite might combine with the lepidolitic compound and they would yield three of a polysilicate (Li, K, Na) $AlSi^2O^6$, which is simply an orthoclase containing lithium. Such orthoclases are known to occur at various localities. It is also well-known that among the decomposition products of orthoclase, orthosilicates (muscovite, kaolin) are most abundant. These facts evidently suggest that petalite may have resulted from the separation of such a feldspar into two compounds.

The resolution of orthoclase into orthosilicates and other compounds is in progress in all parts of the world. Were disilicic acid strongly electronegative and its compounds of a stable character, one would expect therefore to find disilicate minerals frequently associated with decomposing granite. This expectation is not realized nor does it seem probable that the absence of such compounds is due to their solubility, for microscopical study shows that the separation of silica accompanies the decomposition of the feldspar in most cases.

Such facts seem to me to throw much doubt on the true character of the mineral petalite and these doubts are not resolved by study of the data. Some of the analyses must be considerably strained to give the formula usually accepted;

various formulas have been proposed, and Damour found the composition variable in the same specimen. Professor J. D. Dana* also suggests that a portion of the silica may be basic. On the whole it appears to me that the constitution of this mineral and of the allied milarite is insufficiently established, and that it is not as yet necessary to assume for them an acid not known to exist elsewhere.

The hypothesis that the silicates can be reduced to two series and their combinations would greatly simplify the discussion of eruptive magmas. This supposition would cover nearly the same ground as Bunsen's famous suggestion of a normal pyroxenic and a normal trachytic magma, afterwards more or less differently developed by Durocher and others. Magmas would then be composed of substitution products (acid, normal or basic) of polysilicic and orthosilicic acids.

U. S. Geol. Survey, San Francisco, March, 1889.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Vapor Density of Hydrogen fluoride.*—Thorpe and Hambly have confirmed by further experiments the opinion expressed by them a year or more ago that the process of breaking up by heat of the molecular grouping of hydrogen fluoride in the state of vapor, is analogous to that of acetic acid vapor, and that there is no evidence that a molecule corresponding to the formula H_2F_2 exists through any appreciable range of temperature. The commercial aqueous acid was purified by adding to it a strong solution of potassium permanganate and then potash, and redistilling from a platinum retort. The acid potassium fluoride was prepared either by adding the theoretical quantity of pure potassium carbonate to the hydrofluoric acid in a platinum dish, or by adding to the normal potassium fluoride the required quantity of the acid. The residue after evaporation was fused, and yielded on cooling a white opaque mass only slightly hygroscopic. About 40 grams of this salt were placed in a platinum-iridium retort, fitted, by grinding, to a condensing tube and receiver made of the same alloy. The condensing tube which was 50 cm. long was immersed in a mixture of calcium chloride and ice, which gave a temperature of $-25°$. The receiver was similarly cooled. To determine the vapor density, a platinum vessel of known weight and of a capacity of 288·6 c. c., was placed in a bath of glycerol at the required temperature and connected with the receiver containing the liquefied hydrogen fluoride. On surrounding this receiver with water at 25°, the liquid rapidly volatilized

* System of Mineralogy, 5th Edition.

and filled the vessel with its vapor. The temperature of the bath and the reading of the barometer being noted, the vessel was withdrawn from the bath, allowed to cool and weighed, the necessary corrections being applied in calculating the result. The experiments were made at temperatures varying from 26·4° (which is about 7° above the boiling point of hydrogen fluoride under normal pressure) to 88·1°. The vapor density was found to vary from 25·59 at the lower temperature, corresponding to a molecular mass of 51·18, to 10·29 at the upper temperature, corresponding to a molecular mass of 20·58. The results of the 14 experiments are given in a table, from which values a curve has been plotted, showing the law of the vapor density variation. From this it appears at once that the process of dissociation is a perfectly continuous one, and that if such a molecule as H_2F_2 exists, it must be formed only during a transition process and be capable of persisting only in the presence of definite proportions of molecules both more and less complex than itself. At about 32° the density apparently corresponds with H_2F_2, but the curve gives no indication of statical equilibrium in the neighborhood of this temperature such as would be manifest were such a molecule capable of an independent existence. "At temperatures below this point, the vapor-density gradually increases in a regular manner until at 26·4°, the lowest temperature observed, the vapor-density becomes 1·773 (air=1) equivalent to a molecular mass of 51·2 (H_3F_3=60); as it is heated the vapor behaves like a mixture of a complex molecule H_xF_x or of H_xF_x and H_yF_y molecules with a gradually increasing number of molecules of HF, the process of dissociation being perfectly continuous until the temperature increases to about 60° when the density becomes approximately normal; that is, corresponds to a vapor consisting wholly of HF molecules."—*J. Chem. Soc.*, lv. 163, April, 1889.

G. F. B.

2. *On the decomposition of Potassium chlorate by heat, in presence of Manganese dioxide.*—McLeod has studied the nature of the reaction which takes place in the ordinary method of preparing oxygen by heating a mixture of potassium chlorate and manganese dioxide. He concludes that the mechanism of the action of the manganese oxide on the chlorate is probably as follows: First, the formation of permanganate, chlorine and oxygen according to the reaction $(KClO_3)_2+(MnO_2)_2=K_2Mn_2O_8+Cl_2+O_2$; since chlorine is certainly evolved at the commencement of the action. Second, the permanganate is decomposed by the heat, producing manganate, an oxide of manganese and oxygen; a reaction which may be written in the ordinary way $K_2Mn_2O_8=K_2MnO_4+MnO_2+O_2$. The third stage is not quite so clear. It is very improbable, the author says, that the manganate is transformed into permanganate by the oxygen from the chlorate, for in certain of the experiments in which permanganate and chlorate were heated together, manganate remained in the residue. He regards it as more likely that the manganate is acted on by more chlorine produced by the action of the peroxide on fresh

chlorate thus, $K_2MnO_4 + Cl_2 = (KCl)_2 + MnO_2 + O_2$. Indeed he has found that on passing chlorine into the residue obtained by heating potassium permanganate, this residue being heated in the vapor of mercury, the chlorine is absorbed and oxygen is evolved. But here however the action goes further, the manganese being also transformed in part into chloride. That this change does not take place in the preparation of oxygen is evident from the fact that the solution obtained by extracting the residue with water does not contain manganese; and moreover, manganous chloride in presence of potassium chlorate at a high temperature is immediately converted into an oxide with evolution of chlorine. The absorption of the chlorine by the manganate too accounts for the very small quantity of chlorine finally obtained, amounting in the author's experiment to only 6 per cent of the peroxide as a maximum, and this in an exceptional case; the probable average being not over one per cent.—*J. Chem. Soc.*, lv, 184, April, 1889.

G. F. B.

3. *On the synthesis of Formic aldehyde.*—JAHN has succeeded in effecting the direct synthesis of formic aldehyde in a very simple manner. In the course of his investigations upon the volumetric determination of hydrogen by means of palladium he observed that the presence of carbon monoxide exerted a disturbing action upon the occlusion of the hydrogen. Attributing this effect to the possible direct union of the carbon monoxide with the hydrogen under these conditions, he repeated his experiments with suitable modifications and passed a mixture of carbon monoxide and hydrogen over palladium sponge, and then through potash bulbs containing water. Although very little condensation took place, apparently, the water acquired a weak odor of aldehyde; and the solution, obtained from two liters of the gas mixture, gave very distinctly the reducing action characteristic of aldehyde and produced an excellent silver mirror. In view of the synthesis of the sugar formose $C_6H_{12}O_6$ by Loew by the action of calcium hydrate on formaldehyde, this synthesis of the latter substance makes it possible to build up a glucose very directly from its elements.—*Ber. Berl. Chem. Ges.*, xxii, 989, May, 1889. G. F. B.

4. *On the identity of Seminose and Mannose.*—A short time ago Reiss showed that a constituent of certain seeds, hitherto supposed to be cellulose, afforded on hydrolyzation a sugar, to which he gave the name seminose. Although its hydrazone showed the closest similarity with that of mannose, yet its behavior with lead acetate led Reiss to regard it as a different sugar. E. FISCHER and HIRSCHBERGER have re-examined the behavior of mannose with lead acetate and have found that contrary to their earlier statement, this sugar is precipitated by lead acetate, and therefore agrees in this regard with seminose. The authors have produced mannosoxime by the action of hydroxylamine hydrochlorate on mannose, and have found its melting point to be between 176° and 180°; Reiss having found 176° for the melting point of seminosoxime. So also the not quite pure

phenyl-hydraxone from mannose fused at 188°, while that from seminose fused at 185°–186°. It seems probable, therefore, that seminose is identical with mannose, thus confirming the view of the authors that mannose exists in the vegetable kingdom in the form of its anhydride.—*Ber. Berl. Chem. Ges.*, xxii, 1155, May, 1889. G. F. B.

5. *On the Synthesis of Uric acid.*—The determination of the constitution of uric acid analytically has promptly been followed by its synthesis. Although Horbaczewski first produced this substance artificially by fusing together urea and glycocine, yet the reaction was complicated, the yield small, and the stages could not be traced. BEHREND and ROOSEN have now succeeded in building up this substance by a series of simple steps all clear and distinct as to their results. As the starting point, isobarbituric acid was employed; a substance already synthesized by Behrend as follows: (1) by the action of aceto-acetic ether upon urea, an ether of β-uramidocrotonic acid is produced; (2) by saponification with potash, the potassium salt of the corresponding acid is obtained, the acid itself splitting into its anhydride and water; (3) this anhydride called methyl-uracil, when treated with fuming nitric acid, yields nitro-uracil-carbonic acid; (4) this, on boiling with water, loses a molecule of carbon dioxide and produces nitro-uracil; and (5) nitro-uracil by reduction with tin and hydrogen chloride, gives partly amido-uracil and partly isobarbituric acid. By the action of bromine water, isobarbituric acid is oxidized to iso-dialuric acid, the ureide of dioxy-pyroracomic acid, $\begin{matrix}NH-CHOH\\ |\quad\quad |\\ CO\quad C{<}^{OH}_{OH}\\ |\quad\quad |\\ NH-C\end{matrix}$. And by heating the isodialuric acid with an equal weight of urea and six times its weight of sulphuric acid on a water bath for five minutes, the uric acid falls as a reddish crystalline powder, which becomes white after washing, dissolving in potash solution and reprecipitating. The yield is about 30 to 32 per cent of the theoretical. The artificial uric acid is identical in its properties with the natural product. This synthesis therefore confirms the constitution of uric acid given by Fischer and Medicus $\begin{matrix}NH-C-NH\\ |\quad\quad ||\quad\quad \diagdown\\ CO\quad C-NH\quad\quad CO.\\ |\quad\quad |\quad\quad \diagup\\ NH-CO\end{matrix}$—*Liebig's Annalen*, ccli, 235, April, 1889. G. F. B.

6. *Crystallized Tungsten;* by ROBERT N. RIDDLE. (Communicated).—In an attempt made in May, 1888, to investigate tungsten alloys of iron, a mixture of powdered Lake Superior hematite and tungsten trioxide in proportion to yield when reduced 75 per cent iron and 25 per cent tungsten, with enough carbon to reduce them both to metal, was put into a graphite crucible, together with sufficient borax to flux the mass, and was intensely heated in a coke fire for several hours. The fire was then banked,

and the crucible allowed to cool gradually through the night. The button, weighing about six ounces after removing the slag, was found to be covered with small, very brilliant crystalline faces. Pieces of the alloy were then broken up, and digested for several days, in hot hydrochloric acid. The crystals unaltered and but very slightly dimmed, remained separated from the mass of the alloy. Except on the one face, the crystals were not brilliant enough to be measured by the reflecting goniometer. Such as could be obtained appeared to be like trigonal prisms, and were inferred to belong to the triclinic system. Their hardness was above 7, so that they easily scratched quartz, and they were quite brittle. Specific gravity, 15½ to 16. Color, steel gray. Analysis showed 99½ to 98 per cent tungsten, with trace to 2 per cent iron. Carbon was probably present but was not determined. After pulverizing, and heating for three days with concentrated hydrochloric acid, the tungsten was not acted on, and the hydrochloric acid contained no tungstic acid. An alloy of tungsten with nickel shows even more tendency to form the crystals of tungsten.

University of Pennsylvania.

7. *Influence of Solar radiation on Electrical phenomena in the Atmosphere of the Earth.*—Sv. Arrhenius concludes, from a series of investigations, that the air irradiated by ultra violet light conducts like an electrolyte. On Peltier's hypothesis that the earth is charged negatively Arrhenius endeavors to explain the electrical phenomena of the earth as the result of solar radiation. The solid and liquid particles suspended in the air carry the electricity which they obtain from the earth by conduction when the air becomes a conductor under the influence of the sun's rays. Feeble electrical currents exist in the air as a result of this carrying process. On cloudy days the fall of potential is much lower than on bright days. Hail is for the most part negative, while snow is occasionally positive because it occurs at periods when the sun's action is the weakest. These facts the author thinks support his theory. The positive fall of potential noticed in morning fogs he believes is due to the sun not having acted on the fog. A table of Quetelet is referred to which shows, from many years' observations, that the monthly mean of the strength of atmospheric electricity is the less the greater the monthly mean of the solar radiations measured by the actinometer. Thunder storms result from the effects of solar radiation, and are most frequent in hot countries, in the summer, and in the afternoons. The lagging of the maximum occurrence of thunderstorms behind the maximum of solar radiation the author attributes to the time required for the charge and the coalescence of individual drops. Cyclonic storms, occurring at night and in winter, are supposed to be brought from southern regions. The yearly and daily periods of atmospheric electricity are in accordance with this theory. Since the greater part of the active solar radiation is absorbed in the upper regions, these must conduct better than the lower layers of air. Since these upper layers of air are moving strongly from west to east round the earth, a conductor would be obtained under the influence of the sun's rays

which would rotate about a magnet—the earth. By unipolar induction electromotive forces must be set up which would drive the electricity in the higher atmosphere from the equator to the pole. The auroræ boreales and the daily variations of terrestrial magnetism would be referred to these phenomena.—*Phil. Mag.*, July, 1889.—*Meteor. Zeitschrift*, v, 297, 1888. J. T.

8. *Disruptive discharges in gases.*—M. WOLF concludes from his investigations that:

(1) The electrical force required for disruptive discharge in different gases, between spheres of 5 cm. radius at a distance of 0·1 cm., increases with the pressure of the gas between 1 and 9 atmospheres.

(2) The increase of electrical force for an increase of pressure up to one atmosphere is for simple gases, oxygen, hydrogen, nitrogen and atmospheric air, inversely proportional to the mean wave-length of the gas molecule.

(3) With carbonic acid gas the product of the increase of electrical force, for one atmosphere increase of pressure, into the mean wave-length is noticeably smaller (about one-half) than with simple gases.

(4) One or more discharges are needed before the normal resistance of the gas is reached. The resistance also is smaller in comparison with that of later discharges the higher the pressure of the gas.—*Ann. der Physik und Chemie*, No. 6, 1889, pp. 306–315. J. T.

9. *Selective reflection of Metals.*—H. RUBENS has carried out at Strassburg and in Berlin under Kundt a research upon this subject. The apparatus consisted of a spectroscope, the eye-piece of which was replaced by a bolometer. By a mechanical arrangement a standard lamp could replace the metallic mirrors from which the light was reflected, and thus a comparison could be made, the lamp being placed in the position of its virtual image. The ratio of the heat measures gave the selective absorption of the mirror under examination for the wave-length λ.

The following table exhibits the results:

	Silver.	Gold.	Copper.	Iron.	Nickel.
0·45 μ	87·0	43·4	53·0	58·7	61·7
0·50 "	88·3	56·1	54·8	57·7	61·0
0·55 "	90·3	71·1	70·0	56·1	62·1
0·60 "	92·7	80·5	77·7	57·6	63·4
0·65 "	93·3	85·3	80·7	59·6	65·8
0·70 "	94·5	90·3	83·3	61·4	67·8
0·80 "	95·2	92·4	85·4	63·6	70·4
0·90 "	95·8	95·2	87·3	64·7	73·1
1·00 "	96·5	96·8	88·9	69·0	77·4
1·15 "	97·0	97·3	89·5	72·3	80·4
1·40 "	97·4	97·0	91·3	74·3	81·7
1·65 "	97·7	97·0	93·0	78·4	83·9
2·00 "	97·3	95·4	93·9	80·5	84·5
2·3 to 2·7 μ	97·0	89·0	95·0	86·6	88·0
2·7 to 3·2 "	98·3	84·2	96·4	89·6	91·7

—*Ann. der Physik und Chemie*, No. 6, 1889, pp. 249–268. J. T.

II. Geology and Mineralogy.

1. *The Tertiary Volcanoes of the Western Isles of Scotland;* by Prof. John W. Judd, Q. J. Geol. Soc., Jan. 9, 1889.—A brief notice of this important paper by Prof. Judd, prepared from an abstract of it in the Geological Magazine of February last, is published on page 412 of the last volume of this Journal. The following are additional facts from the paper. Prof. Judd states that his memoir of 1874 was the outcome of five years' of personal investigation, and that the region has since been his frequent field of study. The present paper reviews the opinions held before 1874, commends strongly the conclusions of Macculloch with reference to the region, points out the divergences of later writers, and then the results of his own researches, confirming in the main Macculloch's views. One of the most important points brought out in that paper was the earliest establishment of the fact that "in a particular area there exists a complete transition of granitic into glassy rock, both in the acid and basic series," that is, "of granites and gabbros into pitchstones and tachylytes," thus establishing the true relation of the so-called *Plutonic* rocks to the *Volcanic*"—making it in that case a relation of identity as regards age, and of difference, but only small difference, in conditions of crystallization. The conclusion was then doubted by most geologists, and rejected by many; but now it is adopted by Prof. Geikie in his memoir on the same region and has gained general acceptance.

In the same paper of 1874, Prof. Judd presented the conclusion, now sustained by Prof. Geikie, that there were five well-marked centers of eruption—namely, Mull, Ardnamurchan, Rum, Skye and St. Kilda—where the eruptions were on a vast scale, attaining great thickness, with great numbers of dikes; "the largest of these intrusive masses, especially the nearly horizontal sheets, consist of gabbro and granite, while the smaller ones, the dikes and the peripheral portion of the great bosses and sheets, pass into dolerites, basalts and 'felstones' that are exactly similar to the materials of the lava-currents;" that "the basic intrusions tend to form wide-spread sheets, while the acidic ones assume those more bulky and lenticular forms for which the name 'laccolites' has since been proposed by Gilbert."

The Tertiary age and subaerial origin of the "Plutonic" and Volcanic rocks were shown in the paper of 1874, and these points also have been sustained by Prof. Geikie in his memoirs, the facts proving that "many of the rocks occurring among the Tertiaries present all the characters which would, if found among older rocks, cause them to be classed as 'porphyrites,' 'melaphyres,' 'diabases.'"

Prof. Judd does not admit that the evidence points to the conclusion that the acidic rocks of the Western Isles are of younger age than the more basic ones, and now holds that the interval between the acidic and basic outflows has no special importance as a period

of quiescence, but that the change was a gradual one. He says: "Some of the 'felstones' are augite-andesites and labradorite-andesites, but little more acidic in character than the olivine-basalts of the great plateaus; and there are abundant examples of lavas of more or less acidic type having been erupted from the central vents from time to time, while the basalts were being ejected. But as I have formerly shown, while the extremely liquid basalts flowed to distances of 40 or 50 miles from their point of origin, the less fluid acidic lavas seldom flowed to distances of more than ten miles and are consequently found confined to the flanks of the volcanoes from which they issued."

The paper treats at length of the question whether the great centers of eruptions were volcanic centers with subordinate fissures of eruption, or merely regions of grouped dikes, and sustains, as before, the former of these conclusions. He refers to the eruptions of Hawaii as favoring the view that very small angles of flow are the ordinary method with basaltic lava-streams. These angles over Mt. Loa and Kilauea vary, in general, from seven degrees to one, and on Oahu and Kauai, in the deep-cut gorges, usually from five degrees to one, and less than one.

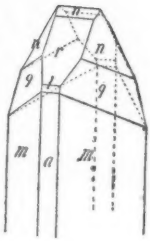
2. *On the Genus Tubicaulis of Cotta;* by Dr. G. STENZEL, Prof. Realgymnasium at Breslau. 50 pp. 4to, with 7 plates, Mitth. Museum, Dresden, 8th Heft. Cassel, 1889, (Theodor Fischer).—This memoir is a full discussion of the fossil tree-ferns of the *Tubicaulis* type, both historical and descriptive, and a defining of species and genera pertaining to it. The *Tubicaulis Solenites* of Cotta, a Permian species, is illustrated by transverse sections on plates 1 and 2, and species of other genera on the following plates. The genera differ in the characters of the internal leaf-stems with their leaf-bundles. The genus Asterochlæna of Corda includes the Devonian species *Asteropteris Novaboracensis* of Dawson. Other genera described are Zygopteris and Anachoropteris of Corda. The earliest species are two of Asterochlæna in the Devonian; the larger number occur in the Permian.

3. *Faune du Calcaire d'Erbray* (*Loire Inférieure*), par CHARLES BARROIS. 348 pp. 4to, with 17 plates. Mém. de la Soc. Geol. du Nord, Tome iii, April, 1889.—M. Barrois, after a stratigraphical account of the region, gives detailed descriptions of 200 species of fossils, with a critical discussion of many questions that come up in connection with them. The faunas of other Devonian regions of Europe are also brought into comparison, so that the work has geologically a continental importance. The relations to the American Devonian, with which he is familiar, are also considered. The figures on the seventeen plates are excellent.

4. *Notes on Epidote and Hanksite;* by DR. C. BODEWIG. (Communicated).—EPIDOTE. The epidote which I bought last summer at Manitou Springs at the foot of Pike's Peak offered at first sight nothing worth publishing. A closer investigation showed that we have here the interesting case of a normally developed epidote.* While the epidote of other localities is developed

* Artini has recently described similar crystals from Elba.—EDS.

in the direction of the ortho-axis, that of Pike's Peak shows a prismatical development. It occurs with calcite on a base of altered pyroxene or amphibole. The crystals are 2–5^{mm} in length and breadth, and though the planes do not allow of accurate measurements, the latter are sufficient to identify the planes. The figure shows the habit of the crystal, which is a twin, with a as the twinning plane. The planes identified are a (100, T), c (001, M), u (210), m (110, z of most authors), e (101), i (102), N ($\bar{3}04$), r ($\bar{1}01$), l ($\bar{2}01$), n ($\bar{1}11$), q ($\bar{2}21$). Some of the measured angles are:



	Calc.	Meas.			Calc.	Meas.
$\bar{1}10 \wedge \bar{1}\bar{1}0$	109° 56′	109° 50′		$\bar{1}00 \wedge \bar{4}03$	64° 29′	64° 14′
$\bar{1}00 \wedge \bar{2}10$	35 29½	35 26		$\bar{1}00 \wedge \bar{1}11$	69 4	69 13
$001 \wedge 00\bar{1}$	50 46	50 50	twin	$\bar{1}11 \wedge \bar{1}1\bar{1}$	41 52	41 57
$101 \wedge 100$	30 23	29 54		$001 \wedge \bar{1}11$	75 11	75 27½
$\bar{1}00 \wedge \bar{1}01$	63 42	63 25		$001 \wedge \bar{2}21$	89 42	89 54

HANKSITE.—A pyramidal crystal with polished planes, and in habit resembling figure 1 on p. 66 of the last volume of this Journal, gave the axial ratio $a:c=1:1{\cdot}00564$, and the following measurements:

	Meas.	Calc.		Meas.	Calc.
oo (pyr.)	=*44° 31′		mo	=67° 44′	67° 44½
co	= 49 15½	49° 16′	ms	=23 12	23 17½

With HCl the substance effervesces; the solution tested with $BaCl_2$ gave only a comparatively small precipitate of $BaSO_4$. A new chemical investigation of the bright crystals may therefore be necessary. The only one in my possession is not pure enough for a chemical analysis.

5. *Plattnerite from Idaho;** by J. D. HAWKINS and EDWIN N. HAWKINS. (Communicated).—In the early part of June, Mr. A. Chanute, Vice-President of the Globe Smelting and Refining Co., collected a specimen of plattnerite from the "As You Like" Mine, near Wallace, Shoshone Co., Idaho, which he gave to us for examination and analysis. The specimen, of the size of a large duck's egg, was superficially coated with limonite, and was of a nodular structure; color iron-black, streak chestnut-brown. The fracture was uneven, and showed a dense structure; hardness between 5·5 and 6, fusibility 2, and very easily reducible to metallic lead. The mean of three close determinations of the specific gravity of the mineral in powder was 7·25. This specific gravity seems to be more in accordance with the specific gravity of Massicot (8·0) than that given by Wheeler (9·46). Two analyses, on 1 and 0·5 grams respectively gave the following results:

PbO_2	90·99			91·03
ZnO	·07			(·07)
Insoluble in HCL.	2·96	SiO_2	2·68	3·00
		Al_2O_3	·28	
Fe_2O_3	5·69			5·86
	99·71			99·96

* Compare p. 79 of the July number.

The specimen was found in a fissure vein in quartzite rock, 100 feet below the surface. As all the lead of the surrounding country exists as galenite, the conclusion seems to follow that the mineral is a direct alteration from the sulphide.

Laboratory of The Globe Smelting and Refining Co., July 18, 1889.

6. *The Minerals of New South Wales, etc.*, by A. LIVERSIDGE, M.A., F.R.S. 326 pp. 8vo. London, 1888, (Trübner & Co.).—A thorough, well digested work on local mineralogy such as Professor Liversidge has given us is of great value to the mineralogical student. The author has already published two earlier memoirs on this subject, but this third edition has a much wider scope and constitutes an independent work. The subjects of the metals, as gold, silver, copper, tin, are treated with especial fullness and have more than a local interest. The author has also included the results of his own original work on many of the species. A large and well executed colored mineral map forms the frontispiece to this unusually handsome volume.

7. *Eighth Annual Report of the State Mineralogist of California*, for the year ending October 1, 1888. WILLIAM IRELAN, Jr., State Mineralogist. 948 pp. 8vo. Sacramento, 1888.—The present issue is the most extended of the series, and gives a detailed account of the mineral resources of the State, arranged according to counties. The number of subjects noticed will be appreciated from the fact that an index of 50 pages is needed to record the names of the different mines, mills, etc., which are mentioned in the volume.

III. BOTANY AND ZOOLOGY.

1. *Beiträge zur Kenntniss der Oxidationsvorgänge in lebenden Zellen;* by Professor PFEFFER, of Leipzig. pp. 141, (from the fifteenth vol. of the Abhandl. der math-phys. Classe der Konigl. Sächsischen Gesellschaft der Wissenschaften. No. V. 1889.)—Professor Pfeffer presents the results of a systematic investigation regarding the action on vegetable cells, of peroxide of hydrogen. The experiments are characterized by his usual thoroughness and breadth of examination. He is led to believe that neither the substance referred to, nor any similar substance furnishing active oxygen, arises in living cells. The same is true of cell-sap. Hence the processes of oxidation in the living cell are effected in some other way than by simple imbibition into the protoplasm. G. L. G.

2. *Biologia Centrali-Americana*, or Contributions to the knowledge of the Fauna and Flora of Mexico and Central America. Edited by F. Ducane Godman and Osbert Salvin. Botany. Introduction (Vol. I, pp. ix–lxi) by W. B. HEMSLEY. Commentary on the Introduction and Appendix, (Vol. I, pp. lxii–lxviii) by Sir J. D. Hooker, and Appendix (Vol. IV, pp. 117–332) by W. B. Hemsley, 1888.—Mr. Hemsley's important addition to existing knowledge regarding Geographical Botany possesses a high degree of interest to American students. It contains analyses of

statistics and comparisons which have not before been attempted owing to scarcity of material. Although it is impossible to give within the narrow limits of this review even a partial idea of the facts upon which Mr. Hemsley's conclusions are based, the endeavor will be made in a future notice to indicate his method of exposition and to state the general results which he has reached. The present short mention can only give a few citations from Sir Joseph Hooker's "Commentary" above referred to, in order to outline two views relative to the primary divisions of the vegetation of the globe. In contrasting the two views, it may be well to keep in mind the practical division made by Mr. Thiselton Dyer, namely, into "Northern, Tropical, and Southern."

Mr. Hemsley's Introduction, with which the Commentary deals, comprises about 50 pages. It is devoted mainly to the presentation of general statistics regarding phanerogamous vegetation, its division into regions, and, especially, a contrast of the flowering plants of Mexico (including those of Central America) with those of India. The approaching completion of Hooker's "Flora of British India" renders this contrast for the first time possible. The areas contrasted are within nearly the same parallels of latitude, namely, 9° N. and 35° N. but they are separated by about 180° of longitude, the American 80° to 115° W., the Asiatic 70° E. to 95° E.

Of these widely separated regions, Sir Joseph Hooker says in his interesting commentary on Mr. Hemsley's work, "Each presents a hot and moist tropical, a temperate, and a frigid climate. It is impossible to find in the Old and New Worlds respectively, two areas more similar as to physical features, or in which the vegetation of their respective continents is more fully represented; and yet the comparison of their floras shows that with an almost total diversity of species genera and of many natural orders, the proportion of monocotyledonous to dicotyledonous plants is nearly the same in each; that the number of natural orders is only 12 fewer in Mexico; that the number of species in each differs by only 2000 (11,626 in Mexico, 13,647 in India); that the average number of genera in each order is nearly the same in each (11 in Mexico and 13 in India) that the average number of species in each genus even more nearly coincides (6·4 in Mexico and 6·0 in India), and more singular still, that the percentage of endemic species in each differs by only 2 per cent. It is instructive to observe that these marked resemblances in proportions do not arise out of a resemblance in the elements from which they are derived; for, turning to the natural orders that contribute most largely to the Flora of each area, they are very differently represented as to the number of species in each. Compositæ, which take the first place in the Flora of the globe and of Mexico, are reduced to the sixth place in India. Leguminosæ, which are second to Compositæ alone, are second in both Mexico and India, but Orchidaceæ, which hold the third place in the world and in Mexico, are first in India; Rubiaceæ, the fourth in the world are

the seventh in Mexico and fifth in India; grasses are fifth in the world and in Mexico, but only third in India. Descending in the systematic scale to the lowest terms of the series, the differences between the elements of the two Floras become greater and greater until genera are reached; thus as Mr. Hemsley shows, only 25 to 26 per cent. of these are common to the two regions. As yet data do not suffice to ascertain the exact number of species common to India and Mexico, but it may not exceed 600 of the 25,273 which is approximately the sum of the species of both Floras." Sir Joseph does not discuss the nature or the origin of these striking likenesses and unlikenesses, but passes in his commentary to a brief account of what he conceives to be the primary Floras of the globe. He limits the primary botanical divisions of the globe to two, the Tropical and the Temperate, and for these primary divisions he suggests the name, Botanical Empires. The regions "next in importance to the two primary are in my view seven,—two north temperate, of the Eastern or Old, and Western or New World, respectively; two tropical, corresponding to the above; and three south temperate (America, Africa, and Australia)." For these regions he proposes the term Kingdom. With regard to "the exact geographical limitations of any of these seven botanical areas, such are possible only where geographical features present insuperable obstacles to the further spread of the plants that characterize them. Where two are conterminous, there is always a neutral ground, often a very broad one, and this neutral ground may itself present a Flora which may be regarded as either tropical or temperate."

Mr. Hemsley on the other hand, with the same statistics before him, proposes a different division. He thinks it possesses certain advantages over that suggested by Wallace for the distribution of animals:—these regions are the following,—(1) Northern, (2) Neotropical, (3) Palæotropical, (4) Andine, (5) Cape, (6) Australian. "The anomalous Sandwich Islands Flora and the fragmentary Antarctic Flora would be unattached in this as in the other."

Mr. Hemsley has given in the appendix a very valuable account of the distribution of the more prominent natural orders, and closes his work by a recapitulation of the dominant features of the Flora of Mexico and Central America, and remarks on its probable derivation. To them we hope to recur later. G. L. G.

3. *A Hand-book of Cryptogamic Botany;* by ALFRED W. BENNETT, M.A., B Sc., Lecturer on Botany at St. Thomas's Hospital, and GEORGE MURRAY, Senior Assistant Dept. Botany British Museum. 472 pp., 12mo, with 378 illustrations. London, 1889. (London and New York: Longmans, Green & Co.)—This small Hand-book covers all departments of cryptogamic botany. The parts on Vascular Cryptogams, Muscineæ, Algæ and Schizophyceæ are by Mr. Bennett, and those on Fungi, Mycetozoa and Schizomycetes by Mr. Murray; but the authors hold themselves "severally responsible for the whole contents of the volume."

This compact, well-printed volume contains a mass of details on the different orders of cryptogams, which will make it a val-

uable reference book for instructors and higher students. But the somewhat encyclopædic arrangement and lack of what may be called general perspective make it unsuited to the large class of students whose knowledge of the subject is elementary. The chief merit of the work is in the unusually full account of Algæ which are copiously illustrated. The part on Fungi is a condensation of other well-known treatises, and the condensation has been carried so far that this portion of the work seems to be crowded into a space quite disproportionate to its relative importance. The attempt of the authors to reform the terminology in common use on the basis of conformity to what they assume to be the rules of English etymology, is by no means to be commended. To let well enough alone should be the rule in science as elsewhere. W. G. F.

4. *Bathymetric conditions as to growing corals and other species of Tizard and Macclesfield Banks, in the China Sea*, by Commander W. U. Moore, R. N. and P. W. Bassett-Smith, Esq., Surgeon R. N.—The facts here cited are from a Report from the Hydrographic Department of the Admiralty, published in March last. On the Tizard bank it was found that live corals in blocks, and of more or less vigorous growth, occurred as far as a depth of 13 fathoms; and in small fragments, as far down as 32 fathoms; but at greater depths than this, no evidence of living corals was obtained with the dredge and swabs used, which "might drag over low blocks of Astræa or Porites without detaching species." "A living specimen of Astræa was found in one of the deepest parts of the lagoon at a depth of 45 fathoms, amongst fine green sand."

Where the section of soundings was through a part of the elevated rim of reef, which reached to the surface of the water, or when it was near such a part, a steep declivity was found somewhere on the slope between 7 and 30 fathoms. The lagoon banks were apparently crowned with dead coral; the floor was covered with sand, and the slope down to it was very gradual.

On the Macclesfield bank, coral was found living as far down the slope as 44 fathoms; it may extend farther, as the work was here suspended. There is no steep declivity at a moderate depth as in the Tizard bank, but there is an extraordinary drop between 65 and 115 fathoms.

5. *The Coral Reefs of the Hawaiian Islands;* by A. Agassiz. Pp. 121 to 168 of vol. xvii of Bulletin Mus. Comp. Zool. Harvard College, with 13 plates. Cambridge, April, 1889.—In this paper Mr. Agassiz discusses the character of the Coral reefs, the elevated reefs, and the results of deep borings in the Hawaiian group. His views and conclusions are an important contribution to the subject of the origin of Coral reefs and islands.

6. *The Fisheries and Fishery Industries of the United States.* Prepared through the coöperation of the Commissioner of Fisheries and the Superintendent of the Tenth Census, by G. Browne Goode, Assistant Secretary of the Smithsonian Institution and staff

of Associations: Section V. *History and Methods of the Fisheries*, in two volumes with an atlas in quarto of 255 plates, volume ii, 882 pp., 4to. Washington, 1887.—The two quarto volumes just issued, one of plates, bear the date 1887, in which year they were ready for the printers, and, like vol. i, were therefore prepared under the active coöperation and superintendence of the late Commissioner Spencer F. Baird, whose name is at the head of the title page. The associate authors with Mr. Goode in the preparation of the volumes of Section V, are nineteen in number, all able in their departments. The subjects treated in the volume just issued are the Whale Fishery, the Blackfish and Porpoise Fisheries, the Seal and Sea-Otter Industries, the Turtle and Terrapin Fisheries, the Crab, Lobster, Crayfish, Rock-Lobster, Shrimp and Prawn Fisheries, the Leech Industry and Trepang Fishery, and the Sponge Fishery and Trade.

The Fish Commission has done a great work for the various industries represented, and incidentally a great work for science in the explorations of the ocean's depths and their species. It is a department in which economical and scientific investigations necessarily go hand in hand, and its results are vastly more important than is generally appreciated.

7. *Darwinism:* an exposition of the Theory of Natural Selection, with some of its applications; by ALFRED RUSSELL WALLACE, LL.D., F.L.S., etc., 494 pp., 12mo, with maps and illustrations. London and New York, 1889 (Macmillan & Co.).—Dr. Wallace, who shares with Darwin the credit of first bringing forward and illustrating the principle of Natural Selection, is the best exponent of the subject living. His own travels and observations over all the world have given him a fund of facts in all departments of science which his familiarity with species, and clear-sighted vision, enable him to use to great advantage in the illustration of the subject. On some important points he diverges from Darwin, and this renders the work more discriminating and of much greater interest. The enquirer as to evolution, desiring to know what it is, and where it tends, should begin with Dr. Wallace's work.

IV. ASTRONOMY.

1. *Researches on the Spectrum, Visible and Photographic, of the Great Nebula in Orion.*—Mr. HUGGINS has communicated to the Royal Society, in his own name and that of Mrs. Huggins, some important observations upon the spectrum of the nebula in Orion. In 1882 he described a new bright line in a photographic spectrum of the nebula, to which he assigned a wave-length of about 3730. Owing to the necessity of using a wide slit a more exact value could not be given.

On the 5th February, 1888, he photographed the spectrum with a narrow slit and found the same line and a pair of less conspicuous lines on the less refrangible side of the strong line. The continuous spectra due to two of the four bright stars or the *trapez-*

ium are also present; across which are at least four groups of bright lines of which the greater number can be traced into the nebula for some little distance from the stellar spectra. Mr. Huggins is led to infer that the stars of the trapezium are not optically projected on the nebula but are physically bound up with it and are very probably condensed out of the gaseous matter of the nebula; also that the nebula as a whole may not be at a distance from us greater than that which we should attribute to such stars if they occurred alone in the heavens.

On the 28th of February of this year he obtained another photograph, using a narrow slit, and was astonished not to find the strong line near 3730. He found, however, the pair that was on the less refrangible side of it, and two other pairs in the more refrangible region of the spectrum.

Mr. Lockyer, in his *Researches upon the Spectra of Meteorites*, has inferred that of seven nebular lines then known three belong to hydrogen and three to magnesium. One of these latter lines, near 5005, is in the visible spectrum, and Mr. Huggins has tested a part of Mr. Lockyer's inference by direct comparison of the magnesium spectrum with that of the nebula. From these, and from various observations of other astronomers, Mr. Huggins concludes "that the remarkable spectrum of the gaseous nebulæ has not been produced by burning magnesium." H. A. N.

V. Miscellaneous Scientific Intelligence.

1. *Elizabeth Thompson Science Fund.*—The following circular has been issued by the Trustees of this fund, of whom Dr. H. P. Bowditch is President:

This fund, which has been established by Mrs. Elizabeth Thompson, of Stamford, Connecticut, "for the advancement and prosecution of scientific research in its broadest sense," now amounts to $25,000. As accumulated income is again available, the trustees desire to receive applications for appropriations in aid of scientific work. This endowment is not for the benefit of any one department of science, but it is the intention of the trustees to give the preference to those investigations *which cannot otherwise be provided for*, which have for their object the advancement of human knowledge or the benefit of mankind in general, rather than to researches directed to the solution of questions of merely local importance.

All applications should be forwarded to the Secretary of the Board of Trustees, Dr. C. S. Minot, Harvard Medical School, Boston, Mass., U. S. A.

It is intended to make new grants at the end of 1889.

*** The trustees are disinclined, for the present, to make any grant exceeding five hundred dollars ($500); preference will be given to applications for smaller amounts.

2. *The Assayer's Manual: an abridged treatise in the docimastic examination of ores, and furnace and other artificial*

products, by BRUNO KERL; translated from the German by W. T. BRANNT. Second American edition, edited with extensive additions by F. LYNWOOD GARRISON. 354 pp. 8vo. Philadelphia, 1889, (Henry Carey Baird & Co.).—This standard and well known work on assaying appears now in its second American edition, increased in completeness and value by the large amount of new and useful matter added by the editor. It gives a clear and concise statement of the methods employed in assaying. The first quarter of the work is devoted to a general discussion of the mechanical manipulations, the chemical processes, assay furnaces, implements and reagents, and the remainder gives the special methods applicable to the different metals. The figures are models of clearness and the whole execution reflects credit upon the publishers as well as upon the editor.

Catalogue of Fossil Fishes of the British Museum, Part I, containing the Elasmobranchii by Arthur S. Woodward, F.G.S., F.Z.S., 474 pp. 8vo, with 17 plates. London, 1889.

La Nouvelle Guinea, IIIe Notice, Le Fleuve Augusta, by Prince R. Bonaparte. 16 pp., with a map. Paris, 1887; and IVe Notice, Le Golfe Huon, 62 pp., with maps.—By the same: Note on the Lapps of Finmark, Paris, 1886, 12 pp.

Glaciation of British Columbia and adjacent regions, by G. M. DAWSON (Geol. Mag., Aug., 1888).

OBITUARY.

JOHN PERCY, M.D., F.R.S.—Dr. Percy, of the Royal School of Mines, the distinguished metallurgist, author of an invaluable series of treatises upon metallurgy, died June 19, 1889, at the age of seventy-two.

MARIA MITCHELL.—Miss Maria Mitchell, the astronomer, died at Lynn, Massachusetts, on the 28th of June, having nearly finished her seventy-first year. The interest which her father, Mr. Wm. Mitchell, of Nantucket, had in mathematics and astronomy, and his telescope, led to the development of similar tastes in the daughter. From the age of eighteen to thirty-eight she was librarian of the Nantucket Athenæum; but her spare time was given to mathematical studies and astronomical observations, and in October, 1847, she made the discovery of a comet, for which she received a comet gold medal from the King of Denmark. In her later astronomical work she devoted herself particularly to the study of the satellites and surface of Jupiter. In 1865 Miss Mitchell became Professor of Astronomy and Director of the Observatory at Vassar College, Poughkeepsie, N. Y., a position she held, with honor to the institution, until January, 1888.

Miss Mitchell was early elected a member of the American Academy of Arts and Sciences of Boston. The degree of LL.D. was conferred on her by Dartmouth College in 1852, and by Columbia College in 1887. On her return from Europe, where she went in 1858 to see observatories, and met with a welcome from many astronomers, she found a welcome back in the form of a telescope purchased for her by American friends.

APPENDIX.

ART. XXI.—*Notice of Gigantic Horned Dinosauria from the Cretaceous;* by Professor O. C. MARSH.

THE remarkable reptiles which the writer recently described, and placed in a new family, the *Ceratopsidæ*,* prove to be more and more wonderful as additional specimens are brought to light. There appear to be two or three genera, and several well-marked species, already discovered, and the object of the present paper is to notice briefly some of their characteristic features so far as investigated.

Triceratops horridus, gen. nov.

The animal described by the writer as *Ceratops horridus*† possesses some remarkable characters not before known in the *Dinosauria*. In addition to the pair of massive horn-cores on the top of the skull, there is a third horn-core on the nose. This is median, as in the Rhinoceros, and is placed on the end of the nasals, which are firmly coössified to support it.

The edentulous premaxillaries are compressed anteriorly, and are strongly coössified with each other and with a third bone in front, which corresponds to the pre-dentary bone below, the whole forming a projecting beak, like that of a tortoise. Over all, there was, evidently, a huge horny covering, like the beak of a bird.

The bone in front of the premaxillaries has apparently not before been observed in any vertebrate, and may be called the rostral bone (*os rostrale*). It is analogous to the pre-nasal ossification of the pig, and of the *Dinocerata*.

Other portions of the skull show features not before seen in the *Dinosauria*. There is a huge occipital crest, extending backward and outward. In the present specimen, this is bent downward at the sides, like the back part of a helmet, thus affording, in life, strong protection to the neck.

* This Journal, vol. xxxvi, p. 477, December, 1888.
† *Ibid.*, vol. xxxvii, p. 334, April, 1889.

The lower jaws are massive, and were united in front by a strong pre-dentary bone. This is pointed anteriorly, and its surface marked by vascular impressions, showing that it was covered with horn, and fitted to meet the beak above.

The skull appears to have been at least two metres in length, aside from the horny beak. It represents a genus distinct from the type of the family, which may be called *Triceratops*. This interesting specimen, which has recently been received at the Yale Museum, was discovered by Mr. Charles A. Guernsey and Mr. E. B. Wilson, in the Laramie formation of Wyoming.

Triceratops flabellatus, sp. nov.

A second specimen of still greater dimensions has since been found at another locality of the same formation, by Mr. J. B. Hatcher. The skull, lower jaws, and a considerable portion of the skeleton, were found together. A striking peculiarity of this skull is the occipital crest, which extends upward and backward, like an open fan. Its margin was armed with a row of horny spikes, supported by separate ossifications, some of which were found in position.

The skull as it lay in the rock measured more than six feet in length, four feet in width, and the horn-cores about three feet in height. These dimensions far surpass any of the *Dinosauria* hitherto known, and indicate to some extent the wonderful development these reptiles attained before their extinction at the close of the Cretaceous.

Triceratops galeus, sp. nov.

A much smaller species is represented by various remains probably from the same horizon, in Colorado. In this species, the nasal horn-core is especially characteristic. It is compressed longitudinally, and its apex is pointed, and directed well forward. It is on the extremity of the nasals, and is thoroughly coössified with them. In front, at the base, it shows indications of union with the premaxillaries, but this connection was slight.

The type specimen was found in Colorado, by Mr. G. H. Eldridge, of the U. S. Geological Survey. The known remains indicate an animal about twenty-five feet in length.

The bison-like horn-cores figured in this Journal (vol. xxxiv, p. 324), probably belong to a member of this group, as already suggested by the writer.* They were sent to him from a locality in which he had himself collected Mastodon remains and other Pliocene fossils. As they agreed in all anatomical

* This Journal, vol. xxxvii, pp. 334.

characters with the remains of cavicorn mammals from that formation, they were referred to the genus *Bison*, under the name *B. alticornis*. The writer has since learned that they were found in the Denver beds, which, although regarded as Tertiary, are probably Cretaceous. Under these circumstances, this well-marked species may be known as *Ceratops alticornis*, until additional remains make certain its true nature.

Nodosaurus textilis, gen. et sp. nov.

Another new member of the *Stegosauria*, from a lower horizon in the Cretaceous, was discovered several years since, in Wyoming, and is now in the Yale Museum. The skull is not known, but various portions of the skeleton were secured. One characteristic feature in this genus is the dermal armor, which appears to have been more complete than in any of the American forms hitherto found. This armor covered the sides closely, and was supported by the ribs, which were especially strengthened to maintain it. In the present specimen, portions of it were found in position. It was regularly arranged in a series of rounded knobs in rows, and these protuberances have suggested the generic name.

Near the head, the dermal ossifications were quite small, and those preserved are quadrangular in form, and arranged in rows. The external surface is peculiarly marked by a texture that appears interwoven, like a coarse cloth. This has suggested the specific name, and is well shown in the cut below.

Dermal ossicles of *Nodosaurus textilis*, Marsh. Natural size.

The fore limbs are especially massive and powerful, and are much like those of the Jurassic *Stegosaurus*. There were five well-developed digits in the manus, and their terminal phalanges are more narrow than usual in this group. The ribs are T-shaped in transverse section, and thus especially adapted to support the armor over them. The caudal vertebræ are more elongate than those of *Stegosaurus*, and the middle caudals have a median groove on the lower surface of the centrum.

The animal when alive was about thirty feet in length. The known remains are from the middle Cretaceous of Wyoming.

New Haven, Conn., July 24th, 1889.

ART. XXII.—*Discovery of Cretaceous Mammalia.* Part II; by Professor O. C. MARSH. (With Plates VII and VIII.)

IN the last number of this Journal, the writer announced the discovery, in the Cretaceous, of many remains of *Mammalia*, and gave brief descriptions, and figures, of some of the more important forms secured.* The present article is a continuation of the same subject, and contains notices of other new species from the same localities, together with some additional information in regard to those first described. In a future article, the relations of these various forms to each other, and to other Mesozoic Mammals will be discussed.

Cimolomys digona, sp. nov.

A species of this genus, somewhat larger than those described, is represented by various remains, the most characteristic of which is the tooth figured on Plate VII, figures 1–4, which may be considered the type specimen. The crown is elongate, rounded in front, and angular at the posterior corners. It is apparently from the left side, and has nine cones in the outer row, and ten in the middle row. In the inner row, there are eleven cones, the posterior ones being minute. The square end of the crown indicates that it adjoined another tooth behind it. This specimen is from the Laramie of Wyoming.

The remains now known of this genus represent a distinct family, which may be called the *Cimolomidæ*.

Selenacodon brevis, sp. nov.

A second smaller species of this genus is indicated by a number of teeth, one of which is figured on Plate VII, figures 9–12, and may be regarded as the type. This tooth is an upper molar, apparently from the left side, and the form of its crown is well shown in the figures named. The front of the crown is rounded and narrow, while the posterior end is broad, and slightly concave, indicating another molar behind it. The valleys between the rows of cones are less deep than in the larger species, a typical molar of which is shown on the same Plate, figures 5–8.

The specimens representing the present species were found in Wyoming, in the Laramie.

* This Journal, vol. xxxviii, pp. 81–92, plates ii–v, July, 1889.

Stagodon nitor, gen. et sp. nov.

The present genus is based on a number of molar and premolar teeth, some of which were found together, but may pertain to separate individuals. The striking character of all the molar teeth secured is the resemblance of their crowns to a drop of viscous fluid, and this is shown in the figure of the type specimen, Plate VII, figures 22–25. This is probably a lower molar, as it has but two fangs.

The premolar represented on Plate VII, figures 17–21, has the same general rounded character, but the form shows its position. This tooth has a portion of the maxillary attached to it. It represents a larger species, which may be called *Stagodon tumidus*.

These remains evidently represent a distinct family, which may be called the *Stagodontidæ*. They are from the Laramie of Wyoming.

Platacodon nanus, gen. et sp. nov.

A number of peculiar teeth, very diminutive in size, have been found in the Laramie. Although evidently mammalian, it is impossible at present to make out their exact affinities. The three teeth represented on Plate VIII, figures 4–12, were found together, and apparently form a series from one jaw. They may be considered as the type. They resemble somewhat, in form, the flattened molars of *Chrysochloris*, but they are more probably premolars. Their main features are well shown in the figures. They indicate an animal about as large as a shrew, and are from the Laramie of Wyoming.

Oracodon anceps, gen. et sp. nov.

A number of peculiar teeth, mostly premolars, represent a very distinct genus, the affinities of which are doubtful. The type specimen is shown on Plate VIII, figures 13–16. It is apparently a lower premolar from the right side, and was implanted by two strong fangs. The crown consists of one main cone, with two small tubercles behind, placed transversely, and three in front. Two of the latter are in the same row with the main cone, and one smaller is on the inner side. The top of the main cusp is worn, mostly on the outside.

This specimen is from the Laramie of Wyoming.

Allacodon lentus, gen. et sp. nov.

The present genus, which appears to be nearly allied to *Allodon* of the Jurassic, is represented by a number of teeth, several of which were found together. The upper molar shown

on Plate VIII, figures 22–26, may be taken as the type. The upper molars secured resemble the corresponding teeth of *Allodon*, but the cones are more pointed, and there is no true basal ridge.

The tooth represented in figures 27–31 of the same Plate may pertain to the same individual as the type. The premolar with three cones, represented in figures 17–21, is referred to the same species, and may belong with the type specimen.

A second, very diminutive, species is represented by several teeth but little larger than those of the Jurassic forms. The type has a crown with four cones, nearly equal. This species may be called *Allacodon pumilus*. All the known remains of this genus were found in Wyoming, in the Laramie.

These fossils evidently belong to the family named by the writer, the *Allodontidæ*, which includes the American genus *Allodon*, and *Bolodon* from the Jurassic of England.

Halodon formosus, sp. nov.

A diminutive species, apparently of this genus, is represented by several specimens, of which the fourth premolar figured on Plate VIII, figures 36–39, may be taken as the type. The crown of this tooth is very low, and elongate. There are eight ridges on the outer side, and twelve tubercles along the upper margin, the two anterior and the two posterior ones having no ridges connected with them.

The lower incisor represented on the same Plate, figures 32–35 probably belongs to this species.

The known specimens are from the Laramie of Wyoming.

Didelphops (*Didelphodon*).

The name *Didelphodon*, proposed by the writer in Part I, for a genus of mammals allied to the modern opossums, proved to be essentially pre-occupied, and was changed in the *errata* to *Didelphops*. A specimen of this genus, apparently belonging to *D. vorax*, has one character that distinguishes it strongly from the genus *Didelphys*. The palate is perforated by a large median aperture. This is not due to imperfect ossification, as seen in the palate of the opossum, and other existing marsupials, but the opening has a well-defined thickened margin. This orifice appears to have been functional, and may represent the posterior nares. If functional, the vacuities in recent forms are probably remnants of the same cavity.

The allied genus *Cimolestes* may be distinguished from *Didelphys* by the fact that the teeth in the lower jaw form a continuous series, there being no diastema.

The fossils here briefly noticed are from the same horizon in the Laramie as those previously described by the writer. Most of them are from the same localities, which have been very carefully explored by Mr. J. B. Hatcher and party. In this work, important aid has been rendered by Dr. C. E. Beecher, assistant in the Yale Museum.

New Haven, Conn., July 25th, 1889.

Explanation of Plates.

Plate VII.

Figures 1–4.—Upper molar tooth of *Cimolomys digona*, Marsh.

Figures 5–8.—Upper molar of *Selenacodon fragilis*, Marsh.

Figures 9–12.—Upper molar of *Selenacodon brevis*, Marsh.

Figures 13–16.—Premolar of *Cimolomys digona*.

Figures 17–21.—Upper premolar of *Stagodon tumidus*, Marsh.

Figures 22–25.—Lower molar of *Stagodon nitor*, Marsh.

Figures 26–29.—Upper incisor of *Dipriodon robustus*, Marsh.

Plate VIII.

Figures 1–3.—Lower incisor of *Selenacodon brevis*.

Figures 4–6.—Tooth of *Platacodon nanus*, Marsh.

Figures 7–9.—Tooth of *Platacodon nanus*.

Figures 10–12.—Tooth of *Platacodon nanus*.

Figures 13–16.—Lower premolar of *Oracodon anceps*, Marsh.

Figures 17–21.—Upper premolar of *Allacodon lentus*, Marsh.

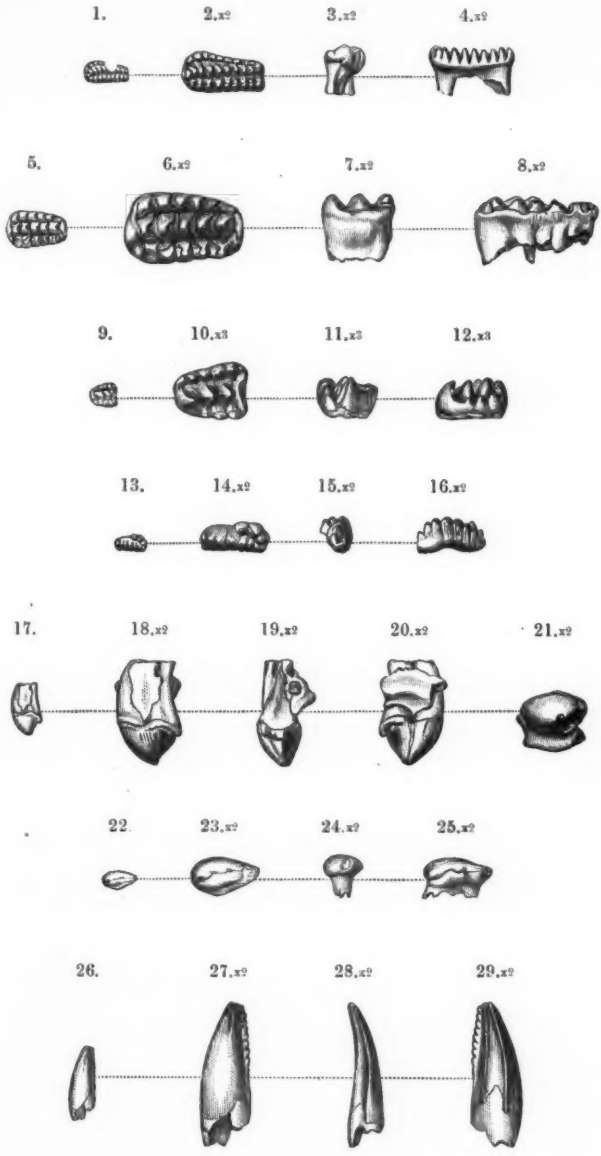
Figures 22–26.—Upper molar of *Allacodon lentus*.

Figures 27–31.—Upper molar of *Allacodon lentus*.

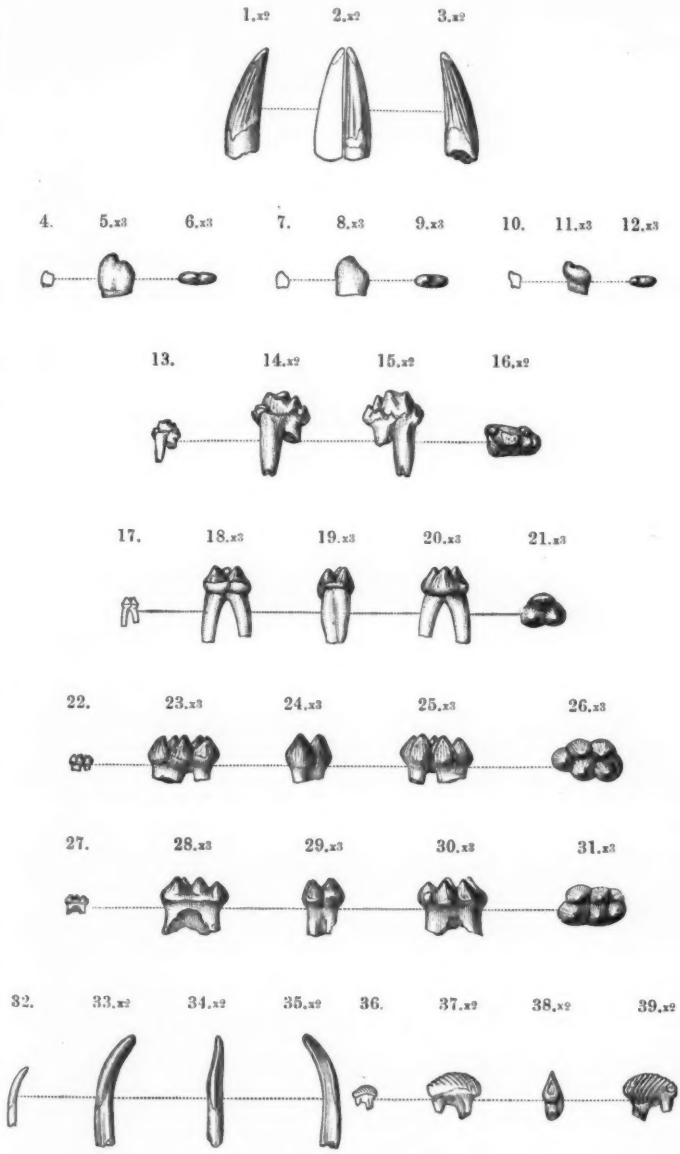
Figures 32–35.—Lower incisor of *Halodon formosus*, Marsh.

Figures 36–39.—Lower premolar of *Halodon formosus*.

Note.—The figures enlarged from natural size have the increase given in diameters over each cut.



AMERICAN CRETACEOUS MAMMALS.



AMERICAN CRETACEOUS MAMMALS.

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